

100 YEARS OF MALARIA CONTROL EFFORTS IN SRI LANKA 1911 – 2011

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Commemorating 100 years of Malaria Control efforts in Sri Lanka



Dedicated to all those who have contributed to malaria control in Sri Lanka (Ceylon), from grass-root level of the implementation of the control programme, to the policy making level.

- Authors -

PREFACE

When introduction of DDT in malaria control succeeded in severe reduction of malaria worldwide, with even complete disappearance from some countries in the west, it was announced that what was achieved was second only to abolition of slavery. That is how the world viewed the problem of malaria. However, if one were to look at the world map indicating the malaria-endemic countries 50 years ago, and those which are still malaria-endemic, the stubborn nature of malaria is clearly evident. In this background, it is not surprising that even present day we have to still talk about malaria control efforts in Sri Lanka, which were studded with periods of great setbacks and periods of near successes.

Sri Lanka has a long story to tell about malaria and the efforts at its control. Fortunately all the events that occurred since the organized attempts at malaria control commenced early in the twentieth century are well documented. Our country (then known as Ceylon) came into limelight even internationally in the area of malaria control when the World Health Organization decided to have Ceylon as a demonstration area in the pioneering days of post-DDT era of malaria control. The 1934/1935 great malaria epidemic in Ceylon is invariably mentioned whenever major malaria epidemics in the world are documented. It is also interesting to note that celebrated personalities such as Sir Ronald Ross (1857-1932) who first discovered that a mosquito is the carrier of malaria, and George Macdonald (1903-1967) who analyzed the 1934/1935 epidemic in detail, while creating the famous Macdonald's Formula much quoted in malariology, were both engaged in malaria control work in this country, in the past.

An attempt is made to document the history of malaria and its control in Sri Lanka, since the commencement of organized malaria control measures. Two major malaria epidemics that took place are described in detail. The attempted interruption of malaria in the country, its near success, later the resurgence leading to a countrywide epidemic, and the subsequent changes in the objectives and strategies at various times are documented.

Mention is also made of the assistance received from the bilateral and multilateral agencies, over the past, which in no small way contributed to the progress in malaria control efforts that has been achieved.

Malaria in Ceylon – until 1934

Views concerning the history of malaria in the country differ. That the disease was probably present in the country during Dutch occupation is suggested by the fact that a map was published by Dutch in 1638, indicating that some 300 years previously Southern province was depopulated and deserted by 'fever sickness', and the North Central province was marked as an area 'depopulated by sickness'. In a publication made in 1921 Dr. Lucias Nicholls, Director of the Bacteriological and Pasteur Institutes of Ceylon, explains that, when Portuguese were obtaining a foothold in Ceylon, at the beginning of the 16th century, the most populated parts of the island were the dry zone in the extreme north, the hill country in the centre, and the lands along the south and west coast. He further states that these were the parts of the country which were either non-malarious or far less malarious than the rest of the country in the nineteen twenties to which the population had aggregated. He postulated that the north-central areas of the country, highly malarious in the twenties, could not have bred or supported the vast numbers of the active race that built and developed its ancient cities, had malaria existed there at that time, and the gradual fall of these people was due to the importation of malaria from India and possibly the anopheline mosquitoes too. He holds the view that the people and their culture drifted to less malarious parts once malaria was established.

Codrington too attributes foreign invasions and to a much greater degree the appearance of malaria, as to have led to collapse of the old works. Dunn expresses a view held by Carter, the first Malariologist appointed to the country, that malaria was already present even before the depopulation of the north central area, and was primarily due to repeated foreign invasions which resulted in disorganization of the highly developed irrigation and agriculture systems. This greatly increased the malaria vector breeding, and the previously manageable prevalence of malaria increased leading to highly endemic malaria. Tyssul Jones attributed an additional factor for the introduction of endemic and hyperendemic malaria into areas where ancient cities existed. He holds the view that in addition to the destruction of the irrigation system which commenced in the 10th century A.D. resulting in much increased malaria vector breeding in irrigation channels and tanks, the increased aridity due to a generalized climate change at the time, which was coincident, too led to prolonged dry spells lengthening the period during which pooling of the rivers took place.

The general consensus of opinion among the historians and demographers is that the major reason for the long period of depopulation of the dry zone, even

in the early part of the twentieth century, was the reluctance of the people to move into environments in which the dark cloud of the scourge of malaria was overhanging.

In the documented accounts of malaria control in Sri Lanka, the attempt made by Dr. A.J. Chalmers to gather definite information on the subject, followed in 1905 by the subsequent publication of results of his investigations, is cited as the starting point of the attempts at malaria control in the country. He revealed information on the indigenous anopheline population in the country, describing 10 species.

A report on malaria fever in the low country was published by Sir Allen Perry, as a sessional paper in 1906, and he also carried out the first spleen survey in Sri Lanka in 1908. A significant step was the appointment by the government in 1910, a Committee to recommend on the possible steps that may be taken to control malaria at Kurunegala. The recommendations prompted the government to commence malaria control measures in the town, with the inauguration of the first anti malaria campaign centre under the direction and control of Dr. S. T. Gunasekera in 1911.

An extremely significant finding was made in 1913 by Lt. Col. S.P. James and Dr. S.T. Gunasekera, while making investigations into malaria in the Mannar Island. They established that *An. culicifacies* is a vector of malaria, by making observations during mosquito dissections they carried out. James & Gunasekera detected sporozoite infection in one specimen of *An. culicifacies* in 1913 while conducting mosquito dissections in Talaimannar, and thus this species was incriminated as the vector of malaria in the country. Carter and Jacocks again detected malaria infection in *An. culicifacies* caught in Ridigama in Kurunegala district. Thereafter, during mosquito dissections this mosquito species was repeatedly found to be infected.

Appointment of a Malariologist

By 1920 the government was planning the establishment of colonization schemes in the North Central province and malaria was viewed as a formidable problem to be tackled if the colonization was to be successful. Dr. Lucius Nicholls, Director of the Bacteriological and Paster Institutes Institute, Colombo, urged the Principal Civil Medical Officer to appoint a Malariologist. Following a request made by the Principal Civil Medical Officer, the Secretary of State for the Colonies appointed Mr. H. F. Carter who assumed duties in June 1921. Drs. K. I. Rustomjee and E. T. Saravanamuttu were assigned to assist him.

Dr. Carter worked from the Bacteriological Institute at first, and subsequently established the office and laboratory in a rented building at Castle Street, from where the workplace was shifted again to Torrington Square, and eventually to Narahenpita. During the next two years the distribution and intensity of malaria in the country were studied, along with a study of the local anophelines and their breeding places.

Entomological Investigations

A great contribution from Carter was the establishment of the anopheline fauna known to occur in the country at the time, comprising the following species,

<i>Anopheles aitkeni</i> , James	<i>Anopheles aitkeni</i> var. insulaeformis, Swell
<i>Anopheles annandalei</i> , Prashad	<i>Anopheles barbirostris</i> , van der Wulp
<i>Anopheles gigas</i> , Giles	<i>Anopheles hyrcanus</i> , Pallas
<i>Anopheles pseudobarbirostris</i> , Ludlow	<i>Anopheles culicifacies</i> , Giles
<i>Anopheles fuliginosus</i> , Giles	<i>Anopheles funestus</i> var. listoni, List
<i>Anopheles funestus</i> var. aconitus, Don	<i>Anopheles jamesi</i> , Theob
<i>Anopheles karwar</i> , James	<i>Anopheles leucosphyrus</i> , Don
<i>Anopheles maculates</i> , Theob	<i>Anopheles punctulatus</i> var. tessellates, Theob
<i>Anopheles subpictus</i> , Grassi	<i>Anopheles subpictus</i> var. vagus, Don

Subsequently, Jayasekera and Chelliah listed 22 species of anophelines, in their compilation of the resident anopheline fauna of the country.

Based on the anopheline species established by him Carter studied the vector bionomics and found that in all the areas studied, paddy fields and irrigation channels were the breeding places for anopheline mosquitoes. *An. hyrcanus* and *An. subpictus* were the predominant species in the fields in all areas, except in the south-western district. In low-country areas in which a high or moderately high spleen rate was recorded, *An. listoni* or *An. culicifacies* were found increasingly both in the fields and in the channels. *An. listoni*

was prevalent in areas where tank system irrigation was practiced, with a higher abundance in irrigation channels than in the fields. In the fallow fields in the drier coastal areas *An. culicifacies* was found in considerable numbers. The latter was also found in the channels in the interior jungle districts. An important observation was that *An. culicifacies* was scanty in both the fields and channels, in the south-western lowlands, which were having only a low prevalence of malaria, and which were not having tank-fed irrigation systems.

Malaria control in Anuradhapura was more difficult than in Mahara or Trincomalie. Paddy cultivation was practiced within the town area over a considerable extent, and necessitated canals and irrigation channels. There were numerous breeding sites in relation to archeological sites as well. Anophelines were found in all types of situations examined, larvae being most commonly found in earth wells, swamps and seepage areas, drains, and paddy fields. *An. culicifacies* larvae were fairly generally distributed, while *An. subpictus* larvae showed some preference to paddy fields, specially when cultivation work was in progress, and to drains, pools, borrow-pits, pot-holes, and to the river. A survey conducted between November 1923 and February 1924, revealed the following relative prevalence of Anopheline larvae, in different breeding sites.

Table 1: Relative prevalence of anopheline larvae, Anuradhapura, November 1923 – February 1924

Breeding place	No. of samples taken	Total larvae	A.listoni	A.culicifacies	A.subpictus	A.hydrocanus	A.barbator	A.fuliginosus	A.jamesi	A.tesseellatus	Unidentified 1st instar	All species
Swamps & seepage pools & pits	1,100	442	4.1	1.3	6.2	7.6	16.1	0.3	1.2	-	3.5	40.3
	940	308	0.6	1.4	5.5	8.5	13.6	0.7	0.9	-	1.7	32.9
Stream & river	1290	242	3.9	0.7	1.5	3.7	6.5					
Wells	1010	906	67.0	-	0.1	1.0	4.2	-	-	1.8	3.4	82.3
Irrigation channels	1820	161	3.7	4.8	1.8	1.2	-	-	0.5	-	2.1	9.3
Paddy fields	2550	1114	2.8	0.4	18.0	15.3	1.3	0.5	0.2	0.04	4.8	
TOTAL	8710	3173	82.1	8.6	33.1	37.3	41.7	1.6	3.3	1.84	17.2	226.7
Average Per 100 samples of all types of breeding places			13.7	1.4	5.5	6.2	7.0	0.3	0.5	0.3	2.9	37.8

Source: Ceylon Sessional paper VII, 1927. Report on "Malaria and Anopheline Mosquitoes in Ceylon" by Henry F Carter (Government Press, Ceylon)

The First Spleen Survey

Sir Allen Perry published a Sessional Paper on malaria, “Malaria Fever in the Low Country”. The latter also carried out the first recorded spleen survey in the island in 1908, which was limited to school children and to children and young persons (upto 15 years of age) attending the dispensaries for treatment, which was later repeated in 1914, 1915, 1916, and 1918.

**Table 2- Results of the 1st Recorded Spleen Survey in Ceylon
(conducted by Sir Allen Perry in 1908)**

Province	Children Examined	Spleen Rate
Western	10,585	22.2
Southern	15,022	18.9
Sabaragamuwa	7,154	28.6
Central	14,362	19.5
North-Western	17,024	53.2
Northern	11,371	39.9
North-Central	5,087	63.2
Eastern	6,476	35.0
Uva	5,177	44.2

Source: Ceylon Sessional paper VII, 1927. Report on “Malaria and Anopheline Mosquitoes in Ceylon”, by Henry F Carter (Govt. Press, Ceylon)

Parasitological surveillance

Carter and his team carried out a preliminary survey between July 1921 and July 1922, visiting a total of about 500 towns and villages, examining representative samples of inhabitants. In the majority of places children below 12 years of age were included in the samples, but in places with sparse population male adults were also included. In the hill-country and estate districts children of resident villagers and not the children of estate labourers were included, for reasons of greater reliability of results. The results revealed considerable variation of prevalence levels within the country. By the examination of a large sample of 11,200 blood smears collected from adults and children, who were patients at the hospitals or dispensaries, the following relative prevalence of the different species was obtained by Carter.

<i>Plasmodium vivax</i>	57.7 %
<i>Plasmodium malariae</i>	33.7 %
<i>Plasmodium falciparum</i>	10.1 %

Epidemiological factors

Investigations made into the epidemiology of malaria in Sri Lanka, during the period 1921 to 1926, revealed following information on:

- Distribution of endemic malaria
- Seasonality of the incidence of malaria
- Prevalence of the different parasite species present in the country
- The role of the indigenous anopheline mosquitoes in the transmission of malaria

Table 3 - Endemic Prevalence of Malaria in Ceylon

Province	Spleen			Blood		
	Children examined	No. positive	Spleen rate	Children examined	No. positive	Spleen rate
Western	18,414	254	1.4	1,068	25	2.3
Southern - Wet Zone	5,052	197	3.7	125	1	0.8
- Dry Zone	1,387	370	26.5	134	14	10.5
Sabaragamuwa	4,437	451	10.2	267	30	11.2
Central - below 500 m	813	152	18.7	144	32	22.2
- 500 - 1000 m	3,443	242	7.0	154	11	7.1
- over 1000 m	744	8	1.1	10	-	-
Uva - below 500 m	245	138	56.3	22	4	18.2
- 500 - 1000 m	1,116	96	8.6	308	43	14.0
- over 1000 m	448	8	1.8	30	1	3.3
Northern -						
a) North and north-western portions of peninsula	4,176	359	8.6	306	43	14.0
b) Elsewhere	3,232	1,034	32.0	342	59	17.3
North-Central	1,807	955	52.7	601	176	28.8
North-Western	5,785	2,084	36.2	754	114	15.2
Eastern	5,273	1,288	24.4	775	131	16.9
TOTAL	56,372	7,636	13.6	5,040	684	13.5

Source: Ceylon Sessional paper VII, 1927. Report on "Malaria and Anopheline Mosquitoes in Ceylon", by Henry F Carter (Govt. Press, Ceylon).

Malaria Control activities -

The organized malaria control activities in the form of a campaign, commenced with the inauguration of the anti malaria campaign centre to cover Kurunegala town, in 1911. The establishment of the first organized anti malaria campaign at Mahara prison in October 1922, was a major event that followed. More anti malaria centres were inaugurated in Anuradhapura and Trincomalie, in May and October 1923 respectively. In 1928 two more anti malaria centres commenced in Kurunegala and Chilaw respectively, and in 1930, another two more in Badulla and Puttalam respectively.

The sessional paper written by Mr. Carter, titled "Report on Malaria and Anopheline Mosquitoes in Ceylon", was published in March 1927. This publication is considered an important milestone in accurately documenting for the first time many features of malaria in the country. After examining representative samples of people from over 500 towns and villages scattered throughout the country, in regard to the state of the spleen and for presence of malaria parasites in the peripheral blood, Carter presented figures to enable the determination of relative intensity of malaria transmission and endemicity in different provinces - Figure 1. It was very clear that the endemicity was higher in the dry zone districts, and he found, at least in some extent, a correlation between the physical and climatic factors of an area, and its endemicity.

Main zones or areas of malaria prevalence

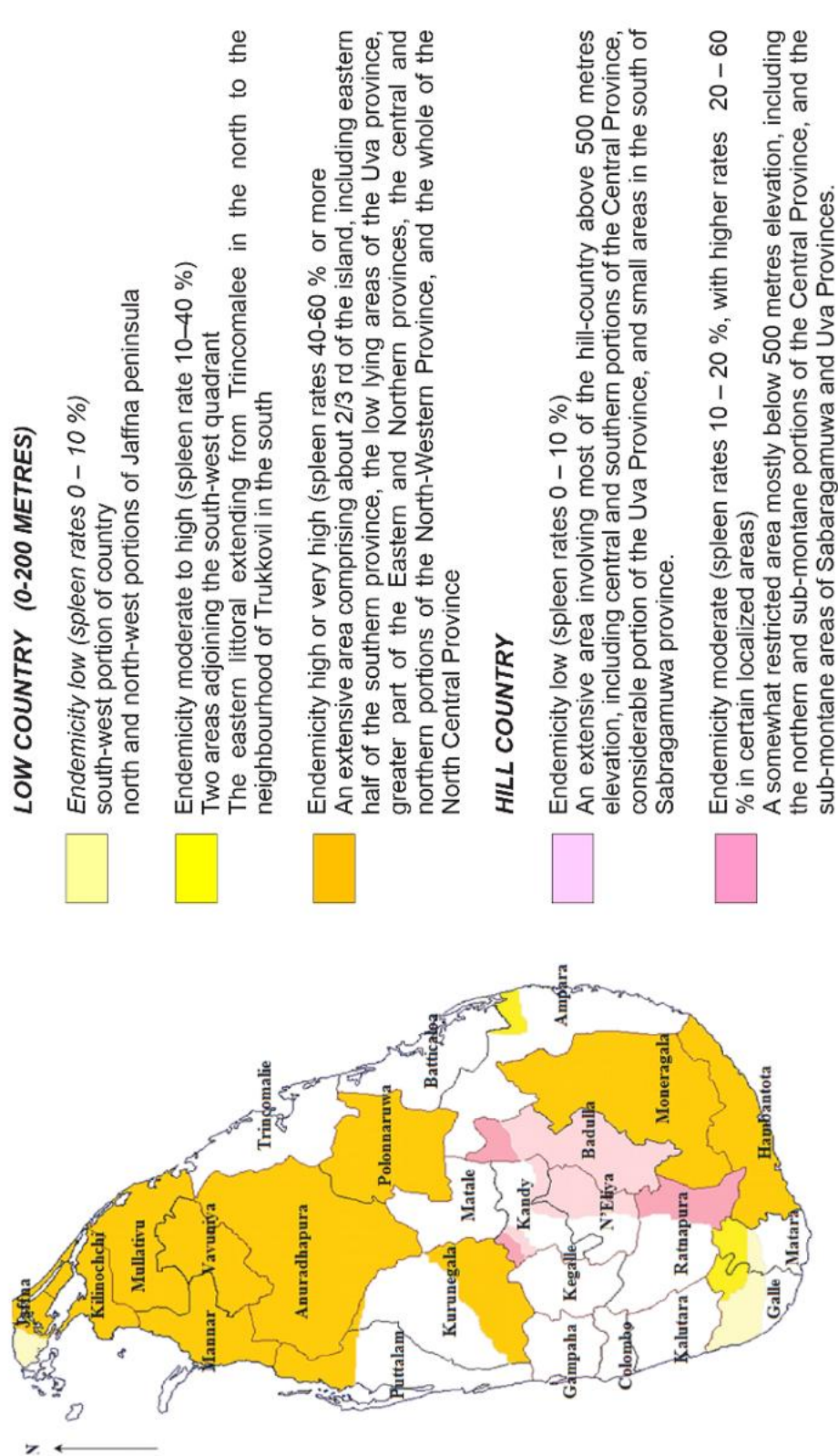


Figure 1 - Malaria endemicity in Ceylon 1927 (Source: Ceylon Sessional Paper V11, 1927. Report on "Malaria and Anopheline Mosquitoes in Ceylon", by Henry F Carter (Govt. Press Ceylon)

Commenting on the malaria control measures which had been carried out during the preceding three years at Mahara Prison, Anuradhapura, and Trincomalee, Carter's report states that the anti mosquito measures were confined to measures such as filling, drainage, oiling, and jungle clearing, except the work on Halpan-ela in Anuradhapura. The malaria control measures in Anuradhapura took a different form as a decision had been taken to implement the measures on an experimental basis, to ascertain whether definite measures targeted against anopheline breeding places would have an effect on the malaria incidence, in highly malarious dry zone areas in which irrigated agriculture was practiced. In 1923 the work began with ordinary measures such as jungle clearing, cleaning of channels and drains, filling of small pools, and oiling, however in 1925 special work commenced on Halpan-ela, a stream which was running through Anuradhapura town, for a distance about 3 miles, and which was very important in removing the waste irrigation water. The work involved reconstruction of the canal.

In Trincomalee situation was different in that the extent of the paddy fields within town limits was small, and irrigation was only by wells. Therefore during the dry season the breeding sites were scanty. A survey of potential breeding sites revealed the presence of anopheline larvae in more than half, the most prevalent species being *An. culicifacies*, *An. listoni*, and *An. subpictus*. Extensive breeding of *An. culicifacies* and *An. listoni* was noticed in the wells, whereas disused paddy fields, borrow-pits, and pools also showed a prevalence of *An. culicifacies*. The malaria control work comprised mainly source reduction work including filling-up, drainage, and removal of undergrowth and brushwood in the neighbourhood of dwellings.

Accordingly the malaria control measures practiced at the time could be summarized as follows :-

- The elimination or material reduction of the malaria carrying mosquitoes
- The destruction of malaria parasites in infected persons
- The protection of man from the bites of infected mosquitoes
- The education of the public in the essential facts concerning malaria and its Control.

Use of larvivorous fish

Use of larvivorous fish was practiced mainly for the purpose of larval control in wells and the temporary rain pools. Fish were introduced to Anuradhapura

from Colombo, and periodically distributed from nurseries. *Haplochilus lineatus* and *Lebistes reticulatus* were the original species introduced, but the former species which had not been naturally found in the neighbourhood of Anuradhapura, failed to thrive, therefore its use was temporarily abandoned. A nursery was constructed for the breeding of the larvivorous fish. A practical problem encountered was that most of the wells in the town had the presence of a carnivorous fish *Ophiocephalus striatus* ('Lula'), which necessitated thorough cleaning of the wells after pump drying, before introduction of *L. reticulatus*. Stocks of the larvivorous fish, *Lebistes reticulatus* were brought in from the nurseries maintained in Colombo and Jaffna, and nurseries were started in turn, in the town of Trincomalee, from which fish were periodically applied to wells. A problem was encountered during the cholera epidemic of April 1925, when the fish in the wells were all killed following the disinfection of the wells, but subsequently the wells were restocked with fish.

It has also been recorded that two species of fish *Gambusia affinis* and *Poecelia reticulata* were imported to the country by the Anti Malaria Campaign during the pre DDT days, for use as larvivorous fish.

Chemoprophylaxis - Administration of quinine

At Mahara Prisons, besides eliminating all unnecessary collections of water such as abandoned wells in the vicinity, and application of larvivorous fish to trenches and wells in use, prophylactic treatment with quinine was administered to all prisoners and staff members and their families, with view to eliminate the parasite reservoir. All new prison inmates who had evidence of malaria or history of malaria too, were administered quinine, considering the fact that the prisoners arrived from districts throughout the country, including from highly malarious ones.

During the North East monsoonal period during the years 1923 and 1924, systematic distribution of quinine to the population in the town was carried out, as an experimental measure. Purpose was to study the feasibility of a prophylactic drug distribution scheme during the peak transmission season, with a view to reduce the rate of primary infections and relapses. Quinine bisulphate was administered bi-weekly to adults and school children. This measure had to be adopted because of the unavailability of resources to detect parasite carriers by microscopy, restricting treatment to only positive cases. The overall results of the prophylactic drug distribution scheme were unsatisfactory as both the acceptance rate and the rate of regular acceptance was poor.

The appointment of a Standing Malaria Advisory Committee

By mid twenties, it was felt that the mechanism for malaria control in the country should be more organized. In 1925 the Principal Civil Medical Officer and Inspector-General of Hospitals, Dr. J.F.E. Bridger, submitted a memorandum to the government proposing that the post of the Malariologist be made permanent, and the necessity for extended research in Medical Entomology in the country. Another memorandum was submitted by Dr. Nicholls, Director of the Bacteriological Institute, regarding a definite policy and organization for progressive malaria control. The government appointed a standing Malaria Advisory Committee, chaired by the Colonial Secretary, and having at an unofficial level several members of the Legislative Council. This amply demonstrates that even in the very early years, malaria control in the island received adequate state attention.

In May the same year, the acting Principal Civil Medical Officer, Dr. Nicholls and Mr. Carter made recommendations to the Committee, as follows :-

- The initial campaign should be of the nature of demonstrations conducted in towns and villages where the disease was highly endemic;
- For a period of 10 years all initial anti-mosquito measures in towns and villages should be carried out by a central malaria organization and not by local bodies and private individuals;
- Local authorities should assist and co-operate in the work and subsequently should be held responsible for the maintenance of anti - mosquito measures on public and private lands within their jurisdiction, the work being done by the central organization on financial contribution recovered from local authorities;
- The central organization should be for some years form a separate branch of the medical department;
- It should consist of 2 sections (a) Executive (b) Research;
- The staff should include a director, a research officer, a sanitary engineer with experience in malaria control work, trained medical officers in charge of individual campaigns, draughtsmen, inspectors of work, field workers, laboratory and office assistants and a labour force.

An important event was that Mr. Carter who had been engaged temporarily for a period of three years only, was granted permanency. Another important landmark the year 1926 witnessed, was the reorganization of the malaria section of the medical department, with Dr. Rustomjee as the first Superintendent, and Mr. Carter's designation changed to that of Medical Entomologist.

The Sanitary Engineering Division of the department was formed in 1927, with Mr. B.R. Dyer, loaned from the Rockefeller Foundation of the United States, heading the division. A main function of this Division was engineering work related to malaria control. The Malaria Advisory Committee which functioned for a period of 3 years was succeeded by the Departmental Committee on Malaria, which had the Assistant Director of Sanitary Services as Chairman, and the Superintendent of the anti malaria campaign, the Medical Entomologist, the Sanitary Engineer, and a Senior Medical Officer from the headquarters, as members.

The approach had to be different in urban and rural areas. In the former in which houses were not much scattered about, but containing a large compact population, and with limited extent of wet cultivation and irrigation channels, anti-larval measures were more cost-effective. These anti-larval measures comprised application of 'oil' or 'Paris green', and environmental measures such as drainage and filling. Sometimes adult spray-killing of mosquitoes was carried out as a supplementary measure. In the selected towns of Anuradhapura, Trincomalie, Kurunegala, Chilaw, Badulla, Puttalam, and Maho, such work was carried out, commencing during the period 1923 to 1934, and the responsible organizations were termed Anti-malaria Campaign centres.

A different situation was experienced in rural areas which were in great majority in the country. Villages were much scattered, and even within villages houses were often far apart. Areas of wet cultivation and potential breeding sites were abundant, making them not amenable to anti-larval measures as the main control method.

Malaria control in Estates

Malaria and hookworm infestations were considered to be two important parasitic diseases affecting the health of the plantation population. The Estate Medical Wants Ordinance which was in operation placed the responsibility of protection of the health of the labourers, with the estate management, though a suggestion to shift the responsibility to the government was under consideration. Sir Ronald Ross the eminent Malariologist and the Director-in-Chief of the famous Ross Institute of London, at the time, visited Sri Lanka in

1926, at the invitation of Ceylon Association in London, to advise on control of malaria on the estates. He recommended two alternative options, viz., either the government malaria control machinery to handle the problem of malaria on the estates, with contributions being made to the government, by the planters, or, the appointment of one or more Plantation Malariologists who would handle malaria control on the estates, in consultation with the government malaria control programme, but supported by the estates. The latter proposal was adopted, and the Ceylon Estates' Proprietary Association Malaria Control Scheme was thus inaugurated in September 1926, on the basis of having to be renewed every three years, until it was made permanent in 1941. Eminent Malariologists from United Kingdom were among the persons who held the post of Plantation Malariologists in this scheme.

The problem of malaria on the estates was mostly seen in the low-country and mid-country, and the control measures comprised those practiced by the government programme at the time, including oiling of rivers and streams running through estate areas, in the dry weather.

Malaria Epidemic - 1934/35

Fairly reliable information about malaria epidemics during the pre DDT era is available subsequent to the enforcement of compulsory registration of births and deaths in 1897. Prior to the great epidemic of 1934/35, there have been periods of excessive mortality coinciding with malaria epidemics except in 1919. These malaria epidemics were in 1906, 1911, 1914, 1919, 1923, 1928, 1929, and 1930. The excessive mortality in 1919 was due to an unusual influenza outbreak resulting in a very high mortality rate. Following a four year period between 1930 and 1933 which were unusually healthy years with respect to the incidence of malaria, year 1934 took a completely different turn. A drought started in the month of April, and the whole island was affected between the months of July and September. The north-east monsoon of 1934-35, too failed. In his book "The History of Irrigation and Agricultural Colonization in Ceylon", R.L. Brohier, describing the weather conditions during the year 1935 states that "even Minneriya tank which in the memory of living man had never been known to be empty, ran almost completely dry". The stage was set for a malaria epidemic. Unfortunately the majority population in the country was not in the best of readiness to meet the catastrophe. The great global depression prevailing at the time had its effects on Sri Lanka too. The export earnings were much reduced, people were laid off their jobs, and things were difficult. The failure of the two monsoons had caused a drop in the country rice production, by as much as 3 million bushels. A famine had set in, and many people were malnourished. An increase in the incidence of malaria was expected, and the Department of Health & Sanitary Services had sent out a warning.

The very first evidence of the approaching epidemic appeared at Alawwa, on the left bank of Maha Oya, in late September 1934. Eventually, by the end of November the entire Maha Oya basin was in the grips of the epidemic. Localities in the basins of five major rivers were altogether affected by the epidemic, viz. Maha Oya, Deduru Oya, Kelani Ganga, Kalu Ganga, and Mahaweli Ganga—Figure 2. However, the most effected was the Maha Oya basin.

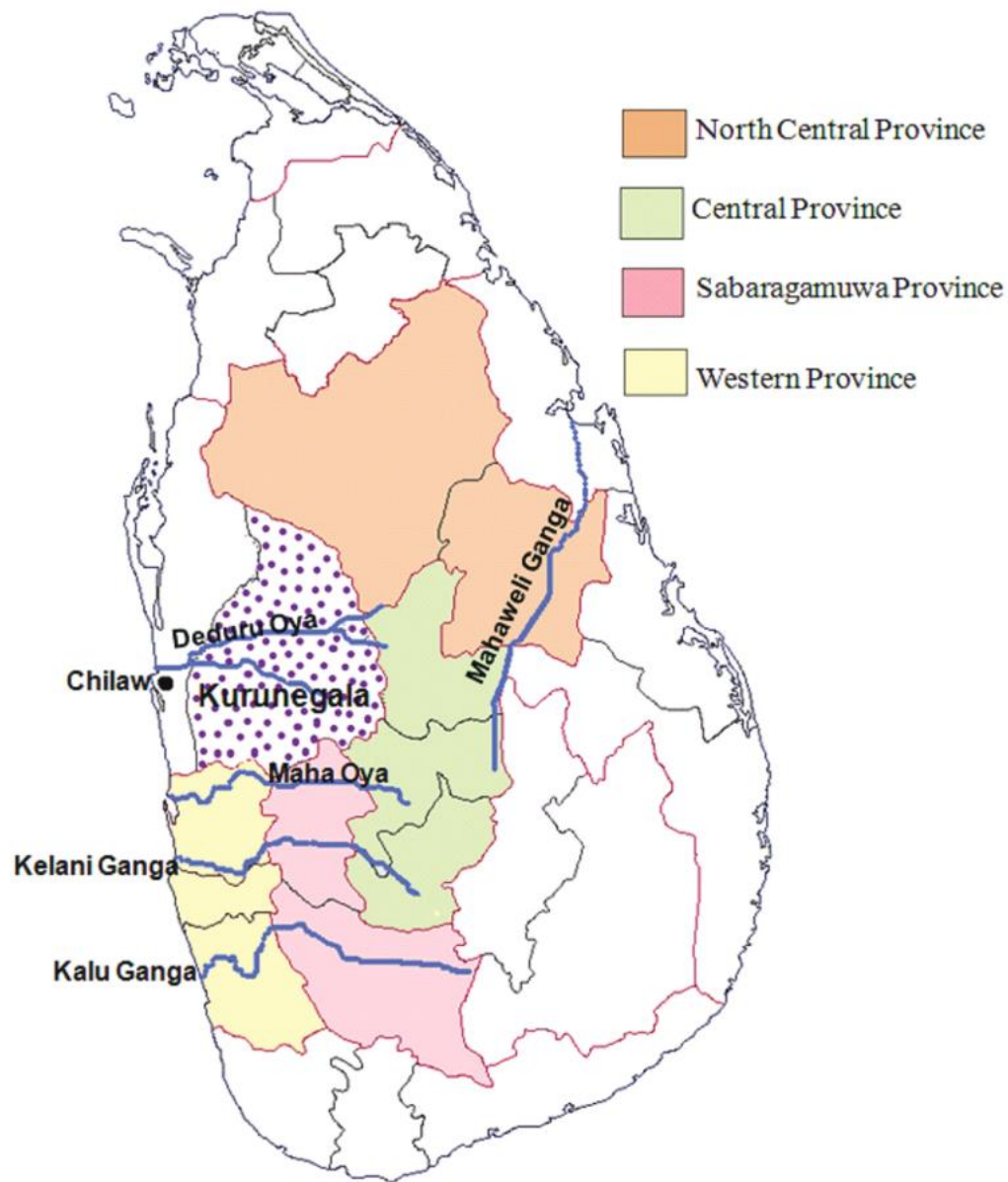


Figure 2 - Districts and the river basins mostly affected in the 1934/35 Malaria epidemic.

By now pandemonium had broken out. Throughout the entire epidemic area the roads were full of people trailing to hospitals and dispensaries, carrying bottles to obtain medicine. One author wrote "whole villages were struck down at once, roads were blocked by victims painfully making their way to the hospitals and dispensaries and the medical department was treating 60,000 new cases a day." Patients were either walking, or being carried in litters, on stretchers, or in bullock carts. Around the hospitals and dispensaries were seen patients crowded, shivering and vomiting from malaria. Following the explosive beginnings of the epidemic the government fully realized that very special and prompt measures were warranted. By the third week of December, additional 261 treatment centres and 429 sub-centres were established to supplement the hospitals and central dispensaries which were normally functioning in the epidemic-affected areas. Every available person from the Medical Department, and personnel from the Sanitary Department, and specialists were requisitioned. To overcome the shortage of accommodation for those malaria patients who required indoor treatment, extra wards were added to the hospitals, and additionally temporary hospitals were established mainly in Government Vernacular Schools. Funds were provided to approve private organizations for the purpose of opening up temporary hospitals and convalescent homes. Several estates in the epidemic area too were affected, and the estate hospitals and dispensaries were assisted by the provision of drugs and funds. Many estates opened up their medical services to the surrounding villages as well. The governments implemented other supplementary measures as well, to help in the situation. Milk products, including malted milk were distributed to under-nourished children. To ease the problem of shortage of meals the malaria patients experienced, temporary kitchens were established at the dispensaries, by Government Agents and private individuals. Free transport was provided by bus and railway to destitute patients and pregnant women, while some private individuals offered the services of their vehicles to transport malaria patients to the nearest hospitals. Once the schools were reopened after the situation improved, the Special Commissioner for Relief made arrangements for free mid-day meals to be provided to the students. Volunteers rendered an unique service. Apart from helping the hospital and dispensary staff in the preparation of meals for malaria patients, volunteer organizations also ran temporary kitchens elsewhere, to provide meals for patients. They also carried out house visits in affected villages, distributing food items and items of clothing.

The epidemic was spread over an area of about 5800 square miles, almost entirely confined to the wet zone, a remarkable feature being that the traditional malarious area of the country, the dry zone, escaping the epidemic. The

district of Kurunegala , a part of the present district of Puttalam (Chilaw area), Sabaragamuwa province, Central province, and the Western province were involved.

Out of the total country population of 5.5 million at the time a population of approximately 3.1 million was living within the boundaries of the epidemic area. The peak of the epidemic over the entire epidemic area was reached during the months of December 1934 and January 1935. Afterwards the epidemic started receding slowly until June 1935, when the South-West monsoonal rains of that year was responsible for the cessation of the epidemic.

- The official figures estimated the number of deaths caused by this epidemic, to 80,000, within a time span of about seven months, however figures up to 125,000 deaths have been quoted in the general literature on this epidemic.
- An estimated 2.5 million to 3.5 million episodes of malaria were reported during the epidemic, signifying that some persons had suffered repeated attacks.

Personnel in the health services were overworked, often working from 7 am until 10pm. Many instances have been recorded where doctors performed their duties with exceptional dedication and self-sacrifice. The District Medical Officer at Padukka is said to have sacrificed his life for the sake of the malaria patients, working very hard single handed while being ill himself, eventually dying of cerebral malaria.

Severity of the disease, and mortality in hospitalized patients

Fernando & Sandarasagara carried out a classic study on 647 malaria patients admitted to General Hospital, Colombo during the epidemic, between November 1934 and March 1935. They categorized 530 patients (82 %) as ordinary type, and 117 patients (18 %) as severe and unusual types.

The latter group was further analyzed by them as follows:

Type	No. of patients
Cerebral	54
Algid	17
Diarrhoeic & dysenteric	11
Respiratory	16*
Oedematous	19*
Total	117

*As respiratory complications they had included those patients who had symptoms like haemoptysis and epistaxis, which they observed were associated with malaria, and not due to any other pathology. Those categorized by them as oedematous type developed rapid oedema but did not have any renal involvement or congestive failure. In all patients oedema disappeared with anti malarial treatment used at the time (quinine or atebrin) 28 of the cases in the series died, thus giving a moratlity rate of 4.3 %.

Anti malarial drugs used during the epidemic

Quinine was the main drug used for treatment of the malaria patients. There was a massive increase in the demand, but obtaining an urgent supply from India, pending further stocks from Batavia and England, medical authorities saw to it that there was no shortage of the drug. The special anti larval measures comprised filling-up the depressions to avoid stagnant water collections in and around towns and villages, and 'oiling' of selected stretches of the rivers containing vector breeding sites.

Malaria in pregnant women

Dr.George Wickremasuriya, an eminent Obstetrician & Gynaecologist who was serving at De Soysa Maternity Home, Colombo, made some very important observations, making use of the unrivalled opportunity to study the case

histories of a large number of pregnant women infected with malaria who were treated at the maternity hospital. At the time the general opinion among the international medical community was that malaria parasites would not cross over to the foetus through an undamaged placenta. Having observed certain abnormal appearances in the placenta delivered by a mother who was affected with malaria, Dr. Wickremasuriya was exploring the possibility of the passage of malaria parasites from mother to the foetus during the pregnancy. He made studies on placentae and babies delivered by mothers who had malaria during pregnancy, and established that not only the parasites could cross over to the foetus through the placenta, but malaria infection of the foetus was not an uncommon cause of death of the foetus. He suggested that congenital malaria should be considered as a separate clinical entity.

Different views on the cause and the mode of onset of the epidemic

Colonel C.A. Gill, was commissioned as an Expert Adviser on malaria, to the government of Ceylon, to report on the 1934/35 epidemic, and to recommend a scheme for the control of malaria in the island. He gave his observations and recommendations in a Sessional Paper, and was of the view that the effect of the drought leading to increased vector breeding was a plausible explanation to the epidemic, but nevertheless, the entomological theory alone would not suffice as the cause for the events that took place during the epidemic. He suggested the possibility of an unknown factor (X factor) probably related to the parasite, operating periodically coinciding with the periodic epidemics occurring in Ceylon. However, George Macdonald, applying a mathematical model, created a synthetic curve based on certain entomological parameters, and found that this curve closely resembled the Deduru Oya Basin epidemic curve drawn, based on real parasitological data collected during the 1934-35 epidemic in Ceylon. Thereafter he concluded that happenings during the 1934-35 epidemic could have occurred if there was multiplication of anopheline density by 5.3 times at a time when conditions are favourable for moderate longevity and on a background of slight transmission only. His view was that abrupt changes in transmission factors alone could explain the epidemic curves seen during the 1934-35 epidemic, and that it would be unnecessary to postulate any other cause.

With regard to the initiation of the epidemic, the view of Col. Gill was that the onset was sudden and explosive, and that initially there was an epidemic of relapses. But Wijerama, who was working as a physician at the General Hospital, Colombo, throughout the epidemic, and had access to data pertaining to the beginning of the epidemic, expressed the opinion that the epidemic was not explosive, but of gradual onset. He reported that the onset was heralded by an increase of primary attacks, based on the severity of clinical manifestations, characteristics of the fever charts, spleen index, percentage of blood smears carrying gametocytes, and the frequency of blood smears with heavy infections, found by him in the malaria patients admitted during the epidemic.

Aftermath of the 1934/35 epidemic

With the abatement of the epidemic the government decided that circumstances which led to the epidemic, and the possible consequences should be studied in detail, and a policy formulated to ensure effective malaria control in the future. Colonel C. A. Gill, an expert in malaria control, with much experience working in India and Myanmar (then Burma) was commissioned to carry out this task, and arrived in the country in April 1935. His *'Report on the Malaria Epidemic in Ceylon in 1934-35; Together with a Scheme for the Control of Malaria in the Island'* was published in September 1935, as a Sessional Paper. He concluded that the epidemic was entirely due to natural factors, and could not have been prevented. He said in his concluding remarks "There is no royal road to malaria control and success is only to be achieved by means of a co-operative effort in which the Government and the people both have an important part to play. It rests with medical science to supply the knowledge, with Government and the Medical Department to provide the machinery, and with the People to contribute the motive power". Colonel Gill's report emphasized on the importance of integrating malaria control measures with the general public health activities in the country, and consequentially the new Malaria Control and Health Scheme was inaugurated in 1936.

Malaria control under the new all-island Malaria Control and Health scheme

The year 1937 saw another milestone in the history of malaria control in the country. With the introduction of the Health Scheme in the island, a set up was established in which Medical Officers of Health, Field Medical Officers, and Sanitary Assistants studied the problems in their respective areas, and carried out the necessary control measures under the supervision of the Divisional Medical Officer, and technical guidance of the Departmental Committee on Malaria, particularly the Superintendent of the anti malaria campaign.

Medical Officers of Health were already carrying out preventive work in urban areas; however the appointment of the Field Medical Officers greatly augmented the country's public health services. Thus resulted an extended general health programme based on the Health Unit system.

'Malaria Week' Celebrations

Mobilization of the community for malaria control activities was an important concept. For this purpose it was necessary to create awareness on malaria among the community, and to achieve this objective, celebration of 'All Ceylon Malaria Week' commenced in 1937. It was an annual event which was later replaced by the 'Health Week Celebration', with the gradual decline of malaria incidence in the country

Special control measures implemented in the pre-DDT era

Adult spray killing

During the 1939/40 epidemic adult spray killing using a mixture containing pyrethrum was carried out in a limited extent. It appeared that this method was suitable for malaria control in rural areas, and colonization, irrigation and agricultural schemes, however obtaining regular supplies of pyrethrum extract was a problem. In fact, a trial in a plantation was attempted at Mahacoodagala. For practical reasons certain villages were selected as central points, to

demonstrate to the community the beneficial effects of pyrethrum-spraying, in the expectation that it would be possible to motivate the villagers to form into cooperative societies and carry out this work themselves, extending the activity into surrounding villages. The insecticide mixture for spraying, and the spraying equipment were to be provided by the central government, at a nominal cost or altogether free of charge.

Oiling of rivers & streams

Shell Malariol was used for the purpose.

Application of Paris green

As an anti larval agent, this chemical, copper aceto arsenite had advantages over 'oiling' in certain circumstances. It could be applied to paddy fields and irrigation channels, which were considered important breeding sites at the time, although 'oiling' was not possible in these sites because of the deleterious effect on paddy plants. Paris green could also be applied in places like wells from which water was taken for drinking. In fact, it had been under consideration even to apply Paris green dust in some selected areas, using aircraft, in the post-war period. .

Automatic siphons

Automatic flushing devices were meant to flush out malaria vector larvae in rivers and streams, and they were installed by the government, for the first time in 1938. There were several types of automatic siphons, and one constructed at cheap cost, discharging 475 gallons of water per minute, was reported to yield very successful results. In estates a large number of s automatic siphons had been built, in places suitable for their functioning for the control of larval breeding.

Malaria control in colonization schemes

Major colonization schemes at the time were in Minneriya, Kagama,

ParakramaSamudra, ya, Elahera, Walawe-left bank, Minipe, Ridibendi-ela, and Iranamadu. Malaria control was a priority problem, both during the preliminary stages of clearing the jungle, and subsequent stage of settlement and cultivation. Personal prophylactic measures, use of a mosquito net, and adult spray killing (using pyrethrum spray) were the important control measures.

Treatment of malaria

Three antimalarial drugs, quinine, atebrin (mepacrine), and plasmoquine were in use. The regimen recommended by the department was the standard government hospital quinine mixture during the first two days, followed by quinine sulphate tablets over the next 5 days. Alternatively, atebrin was administered for 5 days. Plasmoquine was given over 3 days for the purpose of destruction of gametocytes of falciparum malaria, after the completion of the course with quinine or atebrin. The department had made available the malaria treatment widely. The department also had a plan to make available the quinine mixture to homes, through the departmental midwives, for the prevention of convulsions in infants living in endemic areas. The Medical Officers of Health, and the Field Medical Officers too, carried out malaria treatment at their quinine treatment centres conducted in their offices or clinics. For the convenience of the public, quinine mixture was made available with responsible persons such as school teachers, headmen, police officers and clergy, at times when the department had adequate supplies.

By the year 1945, complete course of malaria treatment was available throughout the country at 116 hospital, 281 central dispensaries, 192 branch dispensaries, 375 visiting stations, and 18 cottage hospitals.

Quinine prophylaxis

Before the commencement of the second world war, when adequate supplies of quinine was available with the department, quinine was administered for prophylactic purposes for all school children 5 years of age and below, in highly malarious areas in the dry zone and the intermediate zone. Visitors to endemic areas were also advised to take quinine prophylaxis.

DDT Era Begins

Destruction of the adult malaria vector mosquitoes by spraying chemicals was in practice, but its scope was severely restricted by the short duration of action of such sprays, which necessitated very frequent repetition of spraying, if to be effective. Troops from temperate countries engaged in fighting in the tropics experienced much adverse effects on their health from vector-borne diseases like malaria and typhus, and the scientists were busy looking for chemicals that could be used to destroy the disease-carrying insects. Dichloro diphenyl trichloroethane (DDT) was first synthesized in 1873, but became known for its insecticidal properties only in 1939 after Paul Hermann Muller, a scientist working in Switzerland was attempting to find chemicals that could destroy agricultural insects. After the value of its insecticidal properties in public health was realized it was successfully used for typhus control during the second world war, and later in malaria control too. The long period of duration of its insecticidal activity when deposited on surface, made it suitable for malaria control.

In 1945, which was an epidemic year in Ceylon, the department obtained a limited supply through the courtesy of the Army Services, and the subsequent trials proved its efficacy against the local malaria vector. In September 1945, a proposal made to the government on national level malaria control using DDT was accepted, and so began the revolutionary change in the national strategy for malaria control. The objective was to interrupt malaria transmission as soon as possible by providing DDT coverage to structures in all malarious areas, carrying out the exercise with a high degree of efficiency. The goal was to help the development and the progress of the country and improve the health of the people.

The scheme was inaugurated in the first week of November 1945, with the commencement of indoor residual spraying of houses in Anuradhapura and Kekirawa, two worst affected areas at the time. At the beginning, a solution of 5 % technical DDT in kerosene oil was sprayed by engaging two mobile units. The interval between two successive spray cycles was 4 weeks, during the first two months, but later increased to six weeks. Spraying the DDT solution in kerosene oil was subsequently stopped and instead, a suspension of 5 % DDT, obtained by mixing an 40 % Emulsion Concentrate of DDT, with the appropriate quantities of xylene, and an emulsifier, was used. Spraying a suspension of DDT, obtained by mixing 50 % DDT water dispersible powder (wdp) with water, replaced all other methods of spraying DDT, by the end of 1948. Now the target dosage was 100 mg. per square foot, and the interval

between two successive rounds of spraying was variable, depending on the endemicity of the area and the type of houses found. The interval varied between 6 to 10 weeks.

The DDT spraying programme had to be introduced in stages, due to the difficulty of obtaining the insecticide, spraying equipment, and the necessary transport facilities. However in 1947 the complete scheme was in operation. All areas in which the spleen rate was over 10 %, and the portions of 'healthy' areas which were liable to epidemics, including the basins of rivers and streams running through epidemic-prone areas, were included in the indoor residual spraying programme. Since 1949 Benzene Hexachloride was also used in a few areas, at the dosage of 10 – 11 mg. per square foot, with an interval of 6 weeks between two successive rounds of spraying.

Three types of spraying units were in operation. A truck unit was in-charge of a specially trained Sanitary Inspector, and included 2 or 3 supervisors (overseers) and 12 – 15 labourers. To work in areas in which the road conditions would not allow a truck be taken, a jeep unit was engaged, which was in-charge of a Sanitary Inspector or a driver-overseer. This unit had another overseer to carry out supervision along with the Sanitary Inspector or the driver-overseer, and the number of labourers was not more than 6. A walking unit supervised by an overseer and having a variable number of labourers, worked in areas that were not motorable at all. The immediate supervisor of a whole spraying unit of any type, working in the field, was the Medical Officers of Health, or the Divisional Superintendents of Health, in whose area the unit worked. The Superintendent of the Anti Malaria Campaign, and his assistants, from the Head Quarters, too carried out frequent inspections of the units working in the field.

Each spraying unit was assigned a pre decided number of houses which the unit was expected to complete during the spraying round, according to an approved Advance Programme. Any deviation had to be pre-approved. The average number of houses a sprayman had to spray during the day was 20. The under surface of the roof, eaves, inner surface of walls, and the under surface of furniture, were to be sprayed, along with any sprayable surfaces of outer houses found in the premises. Each house was issued with a householder's cards in which the supervisor had to make entries after the spraying of the house was completed satisfactorily.

The establishment of spraying units was soon followed by the formation of

Vigilance Units, in the endemic and epidemic areas. Each unit comprised an Entomological Assistant and a Field Assistant, and was provided with a motor cycle. Among the main functions of this unit, were monitoring the potency of the insecticide sprayed, and the quality of spraying. 39 stations in the dry zone, 25 stations in the intermediate zone, and 3 stations in the wet zone, functioned as monitoring stations for routine entomological investigations.

A phenomenal success followed introduction of countrywide DDT spraying. By 1952, five years after the launching of the countrywide spraying programme, a ten-fold reduction in the total number of malaria cases occurred, and by the end of further five years, only 10,442 cases were detected indicating a reduction of 96.6 % - Figure-3.

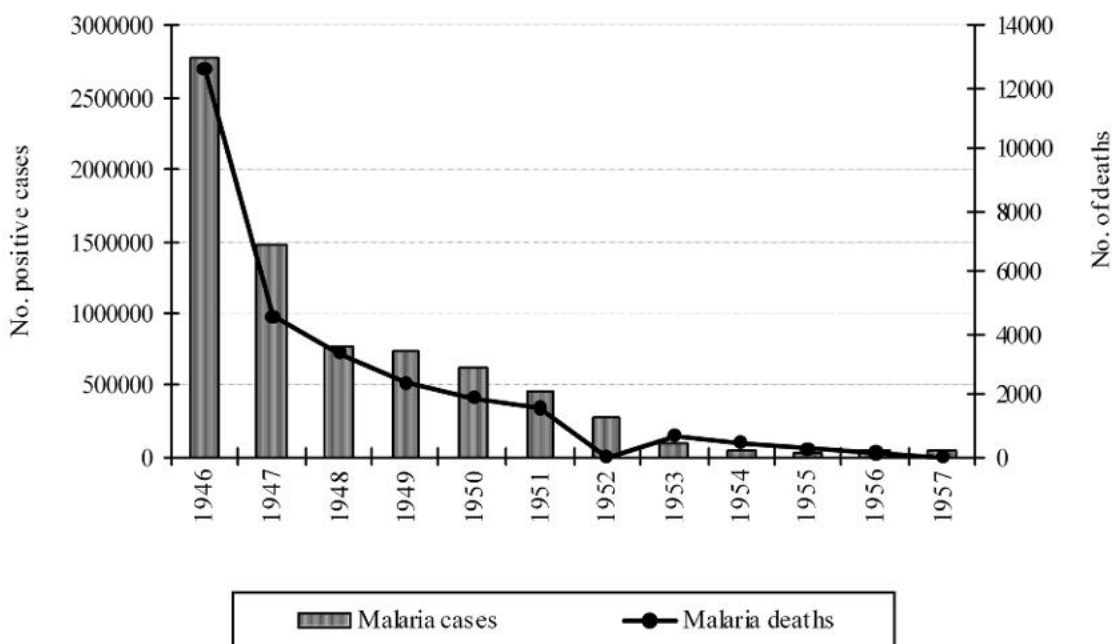


Figure 3 - Malaria Morbidity & Mortality during 1946 -1957

As malaria transmission was getting interrupted the nature of Vigilance Units changed, the Entomological Assistant being replaced by a trained Public Health Inspector, and the Field Assistant, by a labourer trained in house spraying. A jeep was provided for transport purposes, as the labourer had to carry spraying equipment with him. The functions of these Vigilance Units included collection of Anopheline adults from houses (by hand catch and spray catch), and examination of rivers, streams, and potential breeding places in the vicinity of houses, for anopheline larvae. Adult mosquitoes and larvae collected were sent to the central laboratory of the campaign for identification. The Range Public Health Inspectors working in the epidemic zone had to carry out examination for anopheline larvae routinely in fixed stations (sub observation units), and send any specimens collected to the central laboratory. This work of the Range Public Health Inspector also came under the routine supervision of the Vigilance Unit. Other functions of the Vigilance Unit were to inspect sprayed houses for quality of spraying by observation of the deposits on sprayed surfaces and questioning the householders, and by checking the entries on householder's card, to be on the vigil for new chenas and dwellings which had not been visited by the spraying units and to make arrangements for the chena huts and the dwellings to be sprayed, to detect parasite carriers by collecting blood smears from fever cases and other suspected cases, to conduct epidemiological investigations with regard to reported malaria cases, and to carry out mass blood surveys in connection with reported cases.

Prevalence of *An. culicifacies* in the jungles

Following the investigations carried out for the first time to determine the prevalence and status of breeding of *An. culicifacies* away from human habitations, in the jungle, an important finding was that *An. culicifacies* adult mosquitoes and larvae were detected as much as 6 miles away from the nearest dwellings. This confirmed the zoophylic nature of this mosquito, and its presence in the jungles.

Interruption of DDT spraying

By 1951 malaria transmission had got interrupted in both the wet zone and the intermediate zone, and during the year the Truck Unit carrying out spraying in the epidemic zone in Matara was withdrawn. Next year interruption of spraying was further extended to epidemic areas which were covered by the Truck Units at Negombo and Kandy, and to three islands off the dry zone of Jaffna

peninsula. The rest of the epidemic zone in the islands off the dry zone Jaffna peninsula, too had spraying interrupted by the withdrawal of 6 Truck Units, 1 Jeep Unit, and 3 walking Units. Apart from the steep decline in the malaria morbidity in the areas concerned, yet another very important factor which influenced the decision to partially withdraw spraying in the country was the appearance of DDT resistance in the vector in some other countries, leading to a recommendation that insecticide spraying should not be unnecessarily prolonged. At the Malaria Conference held in Philippines in November 1954 the consensus of opinion was that DDT should be used sparingly, restricting its use only to areas with evidence of transmission, with the objective of delaying the appearance of DDT resistance in the vectors. Accordingly, commencing from February 1955 spraying was withdrawn from the entire epidemic area, in urban areas and settled villages in the endemic area.

Establishment of Emergency spraying units

With the large scale withdrawal of spraying, 15 emergency Jeep Units were established, and stationed in Northern, Eastern, North Central, North Western, Southern, Sabaragamuwa, and Uva province respectively. These units carried out spraying in work sites in the developing areas, Land Settlement and Colonization schemes which had commenced within the preceding two years, chena structures, and foci of malaria transmission.

Increased surveillance activities

The now redundant Public Health Inspector and the overseers who had been working in the withdrawn spraying units, were formed into Vigilance Units and Vigilance Sub Units, to serve the areas in which spraying was interrupted. These units working in the epidemic areas paid particular attention to be on the look out for any reappearing vector mosquitoes, and also carried out case detection and case investigation activities. The number of Vigilance Units working in the endemic areas in which spraying was withdrawn was increased. An important function they had to perform was to immediately carry out insecticide spraying in any new chena hut or dwelling detected inside the jungles, without wasting time unduly by trying to get it sprayed by the emergency spraying units. For this purpose some of these Vigilance Units were provided with a jeep and a spraying labourer. In February 1955 the remaining parts of the epidemic zone which were under spray coverage, and urban areas and settled villages in the

endemic zone were deleted from the spray programme. Detection and treatment of malaria cases were greatly augmented by having facilities to take blood smears at the 256 medical institutions which were functioning within the areas in which spraying was withdrawn. 60 malaria overseers who were released from the suppressed spraying units were trained in taking blood smears, and assigned to these medical institutions, for working in rotation spending 2 weeks at a time in each institution. The collected blood smears were sent to the central laboratory for examination. Thirty six Public Health Inspectors, who were released from spraying supervision as a result of interruption of spraying, were detailed to carry out treatment of the malaria cases detected through the examination of blood smears collected at medical institutions, and to also conduct investigation of those cases with view to find out the origin of infection. During their routine visits to villages and visits to investigate malaria foci, these Public Health Inspectors collected blood smears from any fever case encountered by them. They were designated as P.H.I (Vigilance Unit).

Control activities in foci of transmission

Residual spraying was carried out in a focal manner, and systematic blood smear examination and treatment of positive cases were carried out. Once it was established that malaria transmission was present, by the examination of initial blood smears, all persons having fever or with past history of fever were treated as malaria patients. The drug regimen comprised 3 days of amodiaquine and 14 days or 5 days of primaquine depending on whether the case was vivax malaria or falciparum malaria, respectively. To start with, 5 visits were made to administer the 14 day primaquine course, but subsequently the acceptance improved and only 3 visits were made. After the initial survey to detect cases, two more visits at weekly intervals, and two more visits again at fortnightly intervals were carried out to detect cases. Thereafter visits were repeated at monthly intervals. Authorities were of the conclusion that this method succeeded in completely controlling even large foci of transmission.

Aftermath of interruption of spraying

Following the large scale withdrawal of residual spraying a satisfactory state of affairs with regard to transmission control prevailed only during the next eighteen months. By July/August 1956 there was evidence that malaria transmission was rapidly increasing in many districts, most marked being the district of Kurunegala. As the peak transmission season approached towards the end of the year it was obvious that transmission was increasing throughout

the hyperendemic area. Instead of being confined to cleared jungle areas prior to the interruption of residual spraying, now the increased transmission affected the settled villages as well. The vector which seemed to have disappeared in the villages which were formerly covered by residual spraying, had staged a come back, from the jungle areas traversed by rivers and streams. The epidemic zone remained transmission free, as well as the districts of Hambantota and Ratnapura, in the hyperendemic zone. However even in the latter two districts, surveillance over a period of 6 months revealed large numbers of cases being detected at the medical institutions, and the existence of widespread foci of transmission. Therefore residual spraying had to recommence in the two districts. With the resumption of generalized transmission in the hyperendemic zone, following interruption of spraying, the residual spraying programme had to be reintroduced. Systematic case investigation being impossible due to the large number of cases detected, antimalarial drug treatment of the diagnosed cases was the responsibility of the medical institutions, with only one follow-up visits recommended during the course of drug treatment. 4-amino-quinolines and 8-amino-quinolines were made available in the medical institutions.

The measures adopted had well succeeded in controlling transmission again bringing the malaria incidence to comparatively low levels – Figure 4.

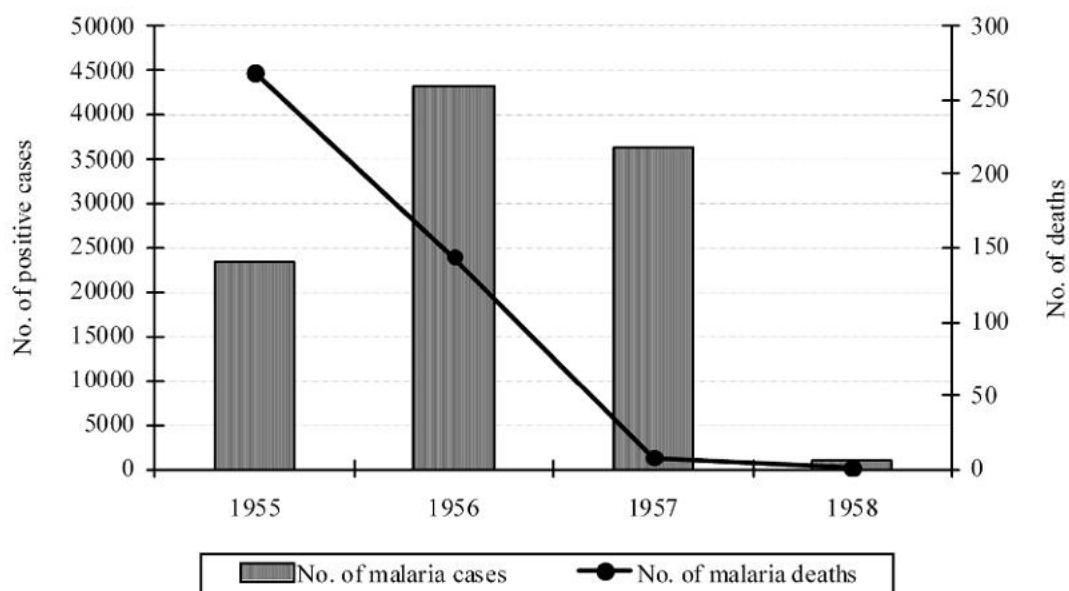


Figure 4 - Malaria Morbidity & Mortality during 1955 -1958

Malaria Eradication Attempt - 1958 - 1963

In view of the successful malaria control achieved by the use of D.D.T, the Government of Sri Lanka first considered the idea of malaria eradication as early as in 1949, but at the time eradication concept was synonymous with vector eradication. The identified local vector, *An. culicifacies*, being present in the jungles too, the idea had to be shelved because of the impossibility of reaching vectors in environments such as jungles.

The definition which had been agreed upon by the International Task Force for Disease Eradication (CDC 1993), referred to eradication at global level, viz., “reduction of the worldwide incidence of a disease to zero as a result of deliberate efforts, obviating the necessity for further control measures”. However, at the time when the government considered eradication at country level, what was meant obviously referred to an alternative definition given to the term ‘eradication’ by Yekutieli that eradication is “the purposeful reduction of the prevalence of a specific disease to the point of continued absence of transmission within a specified area by means of a time-limited campaign”. Presently the term ‘Elimination’ of diseases, has been proposed for the ‘process of reduction to zero of the incidence of infection caused by a specific agent in a defined geographical area, as a result of deliberate efforts, with continued measures to prevent re-establishment of transmission being required.”

The 8th World Health Assembly launched the global malaria eradication campaign, following which the sixth WHO Expert Committee on Malaria, in their report published in 1957, introduced the principles and practice of malaria eradication. This was the DDT era of malaria control, when many countries including Sri Lanka had already experienced spectacular results with indoor residual spraying of houses, using DDT. Major colonization schemes like Minneriya and Galoya Colonization schemes no longer suffered setbacks due to malaria, and generally the dry zone of the country, previously depopulated because of malaria, was gradually been repopulated. But there was a disturbing phenomenon for the Malariologists world over, that the insecticide resistance in the malaria vectors was spreading.

The Director of Health Services, in his Administration Report for the year 1958 said “Malaria though effectively controlled continues to menace the country. There was resurgence in the three years which followed the interruption of residual spraying of houses early in the year 1955 until it was brought under control again in the latter part of 1958. In order to do this, residual spraying had to be reinstituted in the whole dry zone (endemic areas) combined with

drug therapy at a cost of 79 cents per head of the population. This experience demonstrated the danger of interruption of spraying before transmission has been stopped and adequate machinery for surveillance is set up to detect the residual foci and to deal with expeditiously any infection introduced from these foci into malaria free areas.”

Were conditions conducive for an eradication attempt?

Certain important preconditions have been formulated, as necessary to undertake the eradication of a disease. When the concept of eradication of malaria was seriously considered by the countries that had experienced spectacular success following the use of DDT, it was a very reasonable assumption that the health authorities made to embark on malaria eradication in Sri Lanka.

Pre-conditions necessary for undertaking an eradication programme:

- There should be a control measure that is completely effective in breaking transmission, simple in application, and relatively inexpensive;
- The disease should have epidemiological features facilitating effective case detection and surveillance in the advanced stages of the eradication programme;
- The disease must be of recognized socioeconomic importance;
- There should be a specific reason for eradication, rather than control, of the disease;
- There should be adequate financial, administrative, manpower, and health service resources;
- There should be the necessary socioecological conditions.

Malaria being a disease that battered the country, with several severe epidemics in the past, contributing much to the retarded development and depopulation in the dry zone, and causing a considerable drain on the health budget, the government and the health policy makers at the time took an obvious step in the right direction when it was decided to embark on malaria eradication. Residual

spraying with DDT looked a promising tool for the interruption of transmission in Sri Lanka, and malaria vector resistance to DDT which had already appeared in some countries was an important signal that any programme relying on DDT to interrupt transmission, has to implement it soon.

Table 4: Malaria cases detected by the Anti Malaria Campaign in 1957, the year preceeding the launch of eradication programme

District	No of blood smears examined	No positive	District	No of blood smears examined	No positive
Colombo	487	14	Jaffna	5324	284
Negambo	575	6	Mannar	5591	367
Kalutara	5	3	Vavuniya	5774	312
Kandy	5314	121	Bataloa	13899	736114
Matale	6333	782	Trincomalee	2597	114
Nuwara Eliya	1247	7	Kurunegala	9845	1876
Galle	4	0	Puttalam	1786	51
Matara	884	7	Chilaw	2760	38
Hambantota	6260	22	Anuradhapura	11838	1057
Badulla	11649	640	Tamankaduwa	3000	348
Ratnapura	8578	12	Kegalle	2207	14
Total No. of smear examined			= 103,597		
Total No. blood smears positive			= 7,504		

Source: "Experiences of Ceylon's Malaria Eradication Programme." L.F. Gunaratna, Superintendent, Anti Malaria Campaign; 1958.

* The present Moneragala district had been included under Badulla district at the time.

Note: the surveillance system was limited to a system whereby in the 256 medical institutions functioning in the area where the residual spraying had been withdrawn, blood smears were taken from all fever patients, on a rotational basis. Sixty foremen released from their duties in the spraying units, and trained

to take blood smears, had 4 to 6 medical institutions assigned to them, which they visited in rotation, spending 2 weeks at a time in each institution.

Commencing Malaria eradication programme

A 5-year malaria eradication programme commenced on 2nd December 1958. The inauguration was marked by a ceremony at which the representative of His Excellency The Ambassador of United States in Sri Lanka, handed over to the Hon. Prime Minister, 34 jeeps which was a part of the gift from the ICA, to the Eradication Programme.

Preparatory phase - because of the preparatory groundwork that had been accomplished during the long period of intensive malaria control activities in the country, such as geographical reconnaissance, procurement of insecticides and spraying equipment, training of personnel, the preparatory phase was skipped.

Attack phase - entire dry zone was placed under the attack phase, the major activity aimed at interruption of transmission being indoor residual spraying of house with DDT. Experimental studies which had been carried out by the Entomology Division had revealed that DDT sprayed at a dosage of 50 mg / sq. ft was effective against anopheline fauna, for a period of 6 months, and if sprayed at a dosage of 100 mg / sq ft, effective at least for a period of 10 months. In the first year of operation, passive case detection was introduced, and by the end of the second year active case detection was in place, on a total coverage basis, in rural areas.

Consolidation phase - there was overlapping of the attack phase with the consolidation phase, as transmission seemed to have been already interrupted in the intermediate and wet zones, at the commencement of the Eradication Programme, and therefore these two climatic zones were placed directly under the consolidation phase. The emphasis was on passive case detection, and active case detection in areas bordering the hyperendemic zone of the dry zone, and in other vulnerable areas.

Initial response

As measured by the number of microscopically positive cases detected by the surveillance mechanism, there appeared to be a spectacular effect towards arrest of transmission – Figure 5.

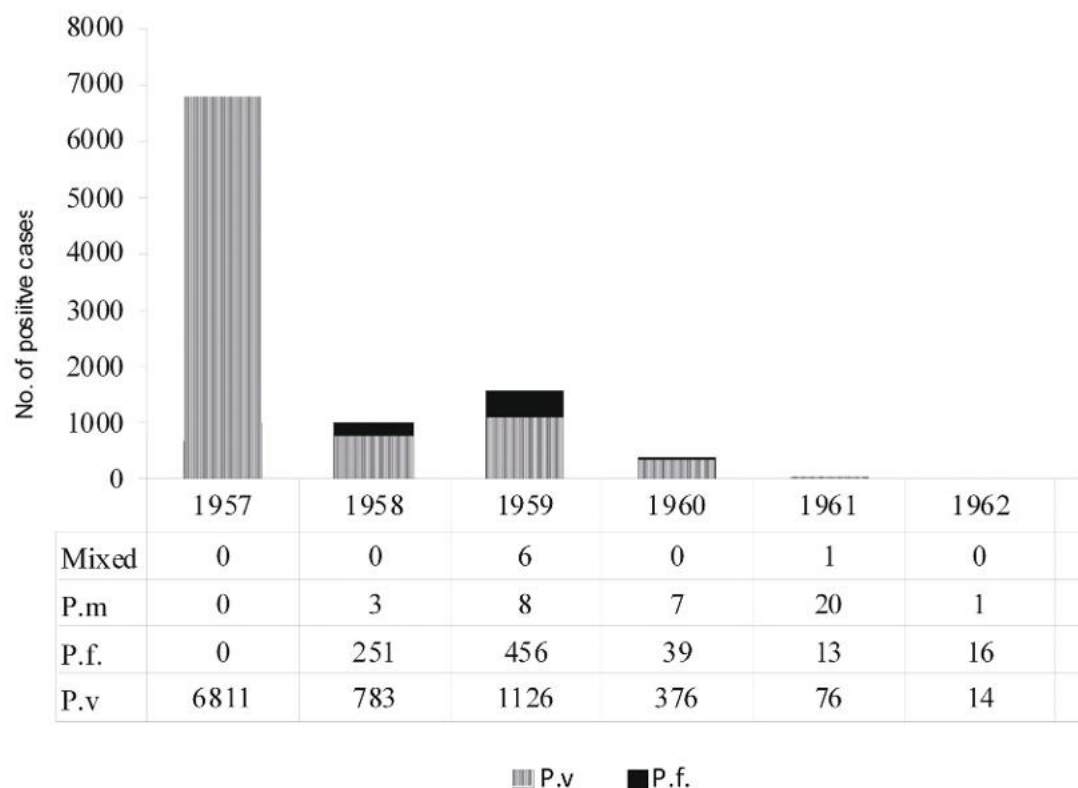


Figure 5 – Microscopically confirmed Malaria cases reported during 1957 – 1963

In 1962 only two foci of active transmission were detected, while the Annual Blood Examination Rate (ABER) was very satisfactory (15.7%). In April 1963, a partial withdrawal of residual spraying was effected, and in the following year no active foci of transmission were detected, while only 17 microscopically confirmed malaria cases were recorded. The investigation of these 17 cases revealed that only 6 patients had contracted the disease within the country, and the remaining 11 were imported infections. In April 1964 residual spraying was completely withdrawn, and now the entire country was placed in the consolidation phase.

The activities in the consolidation phase included active case detection covering the entire rural population in the hyperendemic zone, and intensive measures to prevent imported infections from other countries, particularly Maldives.

The following remedial measures were carried out whenever a malaria case was detected:

- Residual spraying covering an area of $\frac{1}{2}$ to 1 mile radius around focus;
- Radical treatment to positive and suspected cases;
- Mass radical treatment in close communities with a high infection rate;
- Presumptive treatment of household contacts with one dose of camoquine and pyrimethamine;
- Mass blood surveys within $\frac{1}{2}$ to 1 mile radius of the positive case, and continued monthly for 2 to 4 months;
- Follow up of all positive cases monthly, for an one year period.

Resurgence of malaria

By early sixties malaria was a forgotten disease. Medical students had to learn all about malaria without seeing a single patient. Malaria was not commonly included in the differential diagnosis when considering the diagnosis of a fever patient coming even from previously malarious areas. Children presenting with fever and rigors were investigated for febrile fits, with a blood test for malaria done only late during the investigations. To such an extent malaria was forgotten. But soon things were to change. Malaria made its reappearance slowly, but steadily.

The state of interrupted transmission did not remain for long. Sporadic cases appeared after a few months of total withdrawal of residual spraying, and active foci of *P.falciparum* and *P. malariae* were detected in the 4th quarter of 1964. A total of 392 positive cases were detected during the 12 month period Oct 1964 to Sept 1965, and classified as follows, after investigations:

Locally transmitted cases	Imported cases
361	31 (30 from Maldives, 1 from Nigeria)

District	No. of foci	No. of cases	District	No. of foci	No. of cases
Batticaloa	7 (P.f.) 1 (P.m.)	110 (P.f.) 5 (P.m.)	Matale	1 (P.m.)	3 (P.m.)
			Kurunegala	3 (P.m.)	45 (P.m.)
Ampara	1 (P.m.)	13 (P.m.) 52 (P.f.)	Anuradhapura	3 (P.m.)	18 (P.m.)
			Polonnaruwa	1 (P.f.)	6 (P.f.)
Moneragala	2 (P.f.) 5 (P.m.)	33 (P.m.)	Badulla	1 (P.f.)	3 (P.f.)

The *P. malariae* foci were eliminated by the institution of necessary remedial measures, and because of the alarming degree of falciparum malaria transmission in the Eastern districts, residual spraying was reintroduced covering a population of 0.15 million, thus reverting back these areas to attack phase. The resumption of *P. malariae*, after withdrawal of spraying was significant. Out of the total of 439 positive cases detected during the period, more than half (254 cases) were *P. malariae* cases which were scattered throughout the previously malarious areas in the country, sparing the Northern district.

Table 6: Total number of cases detected during the period – October, 1965 – September, 1966

Locally transmitted				Imported cases (34 cases from Maldives; 5 from Pakistan)			
<i>P. vivax</i>	<i>P. falciparum</i>	<i>P. malariae</i>	Mixed	<i>P. vivax</i>	<i>P. falciparum</i>	<i>P. malariae</i>	Mixed
5	140	254	1	25	13	1	-
Total locally transmitted cases - 400				Total imported cases - 39			
Total No. of Cases = 439							

Imported infections

10 % of the total detected infections being imported ones; measures were taken to guard against such infections, including screening arriving passengers from Maldives, as the threat of importation of malaria from Maldives had been confirmed. Anti mosquito measures were carried out at air and sea ports of entry, by the health authorities concerned.

Transfusion malaria

Out of the *P. malariae* cases detected, investigations revealed that 4 were induced infections, following blood transfusion. The 2 patients detected in Colombo have had blood from the same donor who was resident in Polonnaruwa

district. Malariae parasites are known to remain for very long periods in the human blood, at submicroscopic levels, escaping detection by microscopy.

Among the local foci of transmission, the following foci were significant during October 1965 – September 1966:

District	No. of foci	Species	No. of cases
Kurunegala	1	<i>P.m.</i>	13
	1	<i>P.v.</i>	5
Puttalam	1	<i>P.m.</i>	55
Trincomalee	1	<i>P.m.</i>	17
	1	<i>P.f.</i>	43
Batticaloa	1	<i>P.f.</i>	20
Polonnaruwa	2	<i>P.f.</i>	11
Ampara	1	<i>P.m.</i>	19
Ratnapura	1	<i>P.m.</i>	12
Anuradhapura	1	<i>P.m.</i>	28
	1	<i>P.f.</i>	1

Reappearance of vivax malaria after an absence of 2 years

Detection of a vivax focus in Kurunegala, after an absence of any detected cases of *P.vivax* for a period of over 2 years was most significant, and led to some speculation whether the focus was of simian origin. However, the investigations conducted by the Parasitology Unit of the Faculty of Medicine, University of Ceylon, revealed that it was not so.

Apart from the routine remedial measures which were carried out with regard to cases appearing during the consolidation phase, an additional population of 0.3 million living in the districts of Trincomalee, Ampara, Polonnaruwa, Anuradhapura and Kurunegala, were placed under perennial residual spraying. The number of spray units were increased from 3 to 9. The residual insecticide used was DDT, at a target dosage of 1 g/m². The formulation used to prepare the spray suspension was DDT 75% water dispersible powder. Spraying of the

houses was repeated at 4 – monthly cycles, in areas placed under perennial spraying.

Period October 1966 to September 1967

As compared with the total number of positive case detected during the preceding year (439 positives), a total of 514 positives were detected during the first 9 months, but the situation took a turn to the worst during the next 3 months during which a total of 800 positives were recorded. *P. vivax* became the dominant parasite, by the end of the 12-month period, reaching a percentage of 61.6%. The Anti Malaria Campaign authorities were of the view that this phenomenon suggested the existence of a hidden parasite reservoir in the country population, and also the presence in the country, of a *P. vivax* strain with a long life span.

Most of the outbreaks were detected in new development projects and chena settlements (slash-and-burn type cultivations) in the districts of Kurunegala (*P.v.* 185 & *P.m.* 53 cases), Kandy (*P.v.* 126 cases), Matale (*P.v.* 214 cases), Anuradhapura (*P.v.* 31 & *P.m.* 45 cases) and Polonnaruwa (*P.v.* 90 & *P.f.* 42 cases). By September 1967, Elahera area was a very popular gemming centre attracting gem-miners from all over. This extensive gemming area lying on the banks of Kalu Ganga, in Polonnaruwa district, and bordering Matale district, was included in Matale S.H.S division at the time, but now has been demarcated under the Polonnaruwa RDHS division. A very significant event was the extension of the infections to this gemming centre, in September 1967.

Locally transmitted				Imported cases (10 cases from Maldives; 1 from Pakistan 1 from Tanzania)			
<i>P. vivax</i>	<i>P.f alciparum</i>	<i>P.malariae</i>	<i>Mixed</i>	<i>P. vivax</i>	<i>P. falciparum</i>	<i>P.malariae</i>	<i>Mixed</i>
802	195	304	1	10	1	1	-
Total locally transmitted cases - 1302				Total imported cases - 12			
Total No. of Cases = 1314							

Control measures taken -

1. Case detection and treatment –

Active Case Detection (ACD) – 19% of the total number of blood smears collected by all mechanisms, was by ACD, yielding 115 positive cases (8.7% of the total positives).

Activated Passive Case Detection (APCD) – was carried out in 165 medical institutions, by assigning personnel for the purpose. 65% of the total blood smears collected, and 39.5% of the total positives recorded during the above 12-month period, were as a result of ACD and APCD mechanisms combined together.

Passive Case Detection(PCD) – was carried out in 361 medical institutions, by the members of institutional staff, however it had been observed that all fever patients were not screened in spite of the requirement to do so.

Mass Blood Surveys (MBS) – In addition to mass blood surveys carried out as a part of the case investigation process, this activity covered also Youth Settlement Schemes, Development Schemes, Land Army Camps (existent at the time as a part of the government programme to grow more food), Survey Camps, and other places of labour aggregation. 52% of the total positives during this important 12-month period was through this mechanism.

Commencement of screening of blood donors and recipients (in malarious areas) - Because of the spreading transmission of malaria within the country the above activity commenced during the latter part of the above period. However, none of the smears taken from 7810 donors and 102 recipients revealed any positive for parasitaemia.

Treatment regimens administered -

Radical Treatment -

Species	Treatment regimen
<i>P. vivax</i> & <i>P. malariae</i>	Amodiaquine for 3 days & Primaquine for 14 days
<i>P. falciparum</i>	Amodiaquine for 3 days & Primaquine for 3 days

Mass Radical Treatment was limited to foci of intense transmission.

Presumptive Treatment –

In districts which were formerly malarious, fever patients pending results of blood smear examination, but not having clinical malaria, were given presumptive treatment (single dose of amodiaquine + pyrimethamine). Since there was no transmission detected up to then in the districts in the Northern province, this activity was not implemented in those districts.

2. Residual Spraying –

The number of houses included in the perennial spraying programme was now increased to 118,258 (approx: 0.6 million population), with the addition of 7 new spraying units. Focal spraying was carried out in localities outside the area under perennial spraying, whenever cases occurred, and also in vulnerable areas such as development project areas and re-settlement schemes.

3. Cross checking of blood smears –

In a separate unit, away from the main laboratory, comprising 7 experienced Microscopists and 2 Medical Laboratory Technologists, a system of re-examination of blood smears was established for quality assurance purposes. Ninety six thousand sixty six smears which were reported on as negative at the first examination were re-examined, constituting 6.8% of the total number of blood smears originally examined by the main laboratory. Only 38 of these were found positive on re-examination, giving quite an acceptable negative-to-positive error rate of only 0.04%. Furthermore, 4500 blood smears first reported as negative, were also sent to the WHO Reference Laboratory in Kasuli, India, but the original results were confirmed. Results of cross-checking, both locally and in India, revealed a very competent level of skill in microscopy carried out in the main laboratory.

Malaria Epidemic – 1967/68

The events that took place during the period October 1967 to September 1968 go into the annals of malaria control work in Sri Lanka, the number who suffered from malaria being surpassed perhaps only by the massive malaria epidemic which ravaged the country in 1934/35. Very fortunately unlike during the latter epidemic, the mortality was extremely low. Malaria which was on the brink of being eradicated at the end of a 5 years period after the launching of the Eradication Programme, now erupted in epidemic form, covering the entire dry zone and a large part of the intermediate zone. Localized outbreaks were evident in the wet zone too. Anuradhapura district was very much affected. When Professor Dennis Walder from Newcastle, UK, visited Dr. Kamalika Abeyaratne, the Paediatrician attached to General Hospital, Anuradhapura, Dr. Abeyaratne could show him more than a hundred cases of malaria. Entire villages had been abandoned with the victims shivering in their huts.

Genesis and the spread of the epidemic

The preceding events were the outbreaks of infection in chenas and development projects, involving the districts of Kurunegala, Matale, Anuradhapura and Polonnaruwa, during the latter part of the preceding 12 months. The factor that triggered the explosive epidemic was traced to the extension of the infections to the Elahera gemming centre, in September 1967. This gemming area located in Polonnaruwa district (North Central province) was very popular with gemmers at the time, drawing people from many parts of the country. Consequent to the dry spell of weather prevailing in the area at the time, Kalu Ganga, the river which traverses the gemming area was pooling. The river together with the abundance of stagnant water-filled gem pits spread over an extensive area, created ideal breeding places favoured by the principal vector of malaria in the country (*Anopheles culicifacies*). Realizing the potential of the area to disseminate malaria, the then Superintendent of the Anti Malaria Campaign made a recommendation to the Ministry of Health, to declare Elahera gemming area as a “diseased locality” in October 1967, but this was implemented only in February 1968.

As to be expected there was extensive movement of gemmers to-and-fro between the gemming area and the rest of the country. Once Elahera gemming area became an infected locality, these population movements paved the way for the infection to spread to other areas, causing foci or

outbreaks in localities which had receptivity for establishment of transmission. The team of Malariologists deputed by the WHO, at the request of the Sri Lanka government, to make recommendations for an Emergency Plan and for Long-Term Plan with the ultimate objective of eradication of malaria, in their report, identified a primary epidemic focus which was the Elahera focus, and a secondary epidemic focus (Kataragama focus), an area around Kataragama (Uva province) , the town in which one of the most revered places of worship in the island is located. Kataragama is lying on the banks of a river (Menik Ganga) in the part of Uva province lying in the dry zone, but the malaria control activities, at the time, were handled by the Regional Office which was located in Hambantota district (Southern province), and therefore malaria statistics were included under Hambantota district. Many of the gemmers who were successful in their gemming activities in the Elahera area, subsequently visited the famous shrine at Kataragama, to pay their respects to the divine powers in whom they had faith, and to make offerings. The river having undergone pooling due to the excessively dry weather prevailing at the time, vector was breeding leading to high vector densities in the area thus increasing the receptivity. Initiated by the parasite carriers who came from the primary focus at Elahera, a secondary focus was created in and around Kataragama. Large numbers of pilgrims visit Kataragama from all parts of the country, throughout the year. Dissemination of malaria from Kataragama focus, to rest of the country, therefore was rapid and extensive. The epidemic engulfed the entire part of the country which was formerly malaria- endemic, comprising approximately three fifths of the country and having a population of over 5 million. However, there were differences in the district-wise intensity and the time when the first peak was reached in different districts, as shown in Figure 6.

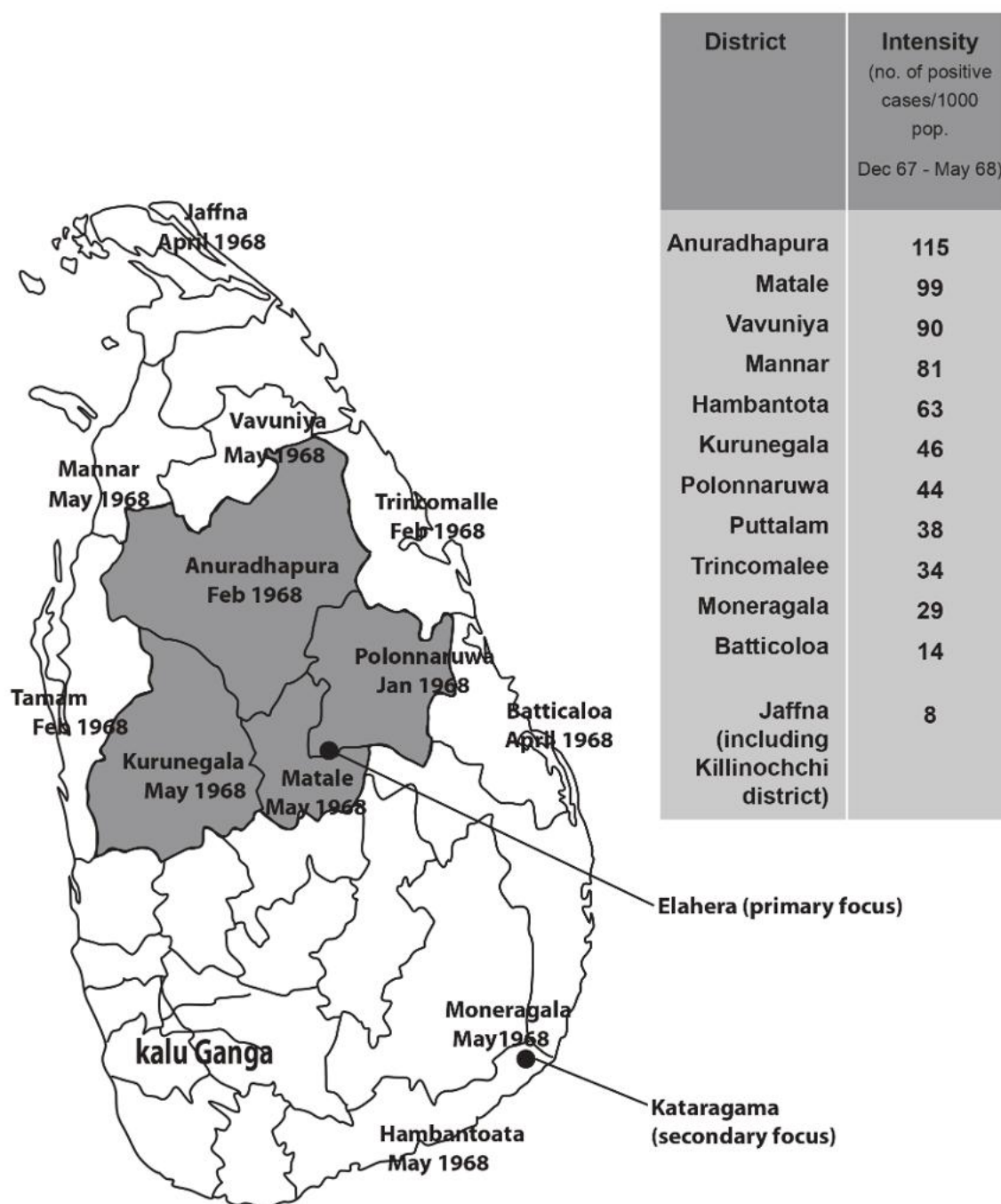


Figure 6 - Intensity of epidemic in different districts during the 1st peak of the epidemic and the time peak was reached in each district (intensity for each district has been calculated as of total positives/1000 population, relevant to the period December 1967 - May 1968)

Emergency plan for control of the epidemic

The team of experts deputed by the WHO at the request of the government, formulated an Emergency Plan in consultation with the Anti Malaria Campaign authorities, which was to be the precursor for an eradication campaign. Estimated cost was Rs. 22 Million.

It was divided into 2 stages:

Stage 1	July 1968 to December 1968
Stage 2	January 1969 to September 1969

From September 1969 (beginning of the Fiscal Year) the regular malaria eradication activities were to commence.

The WHO Advisory Team reported “Seldom, a major epidemic in a tropical country has been so completely dominated by *P.vivax* as in the current Ceylon epidemic”.

They were of the view that following factors were contributory:

- Foci of *P. falciparum* received priority when control measures were instituted.
- *P. falciparum* is the first species to respond to residual insecticide spraying.
- No drug resistance problem was to be expected in treating falciparum malaria cases, because 4-aminoquinolines had been little used during the years of very low incidence of malaria preceding the resurgence. It was further added that inclusion of primaquine in the treatment regimen, would also have had a significant effect on prevention of transmission (by means the gametocytocidal effect on falciparum infections)

Strategies recommended in the Emergency Plan

1. Case detection and treatment –

Surveillance mechanism to be strengthened by APCD and PCD implemented in more medical institutions. During the epidemic more than 99% of the cases were *P. vivax*, a phenomenon very unusual for an epidemic in a tropical country, specially considering the fact that this species was virtually not encountered during the 1964-1966 period.

During the 12-month period a total of 310,104 micorscopically confirmed cases were detected, with the following parasite formula:

<i>P. vivax</i>	309,245 – 99.72%
<i>P. falciparum</i>	652 – 0.21%
<i>P. malariae</i>	197 – 0.07%
Mixed (P.v. + P.f)	10

Changes made to the *P. vivax* drug treatment regimen - In January 1968, at the height of the epidemic, a change was made in view of the impracticability for the malaria control staff to supervise patients who have been prescribed a 14-day course of primaquine, to ensure compliance. The primaquine course was changed from 14-days to 5-days. The 5-day radical treatment regimen (3 days aminoquinolines + 5 days primaquine) introduced at the time around the commencement of the epidemic, was to be continued. All confirmed and suspected malaria cases were to be administered radical treatment at the medical institutions, and additionally by the malaria control officers engaged in ACD in the hyperendemic zone.

Prophylactic Treatment - In project areas, pilgrim centres and in other areas of aggregation of populations, in the malaria-transmission areas, prophylactic treatment was to be administered.

Laboratory Services - Establishment of Regional Malaria Laboratories had already begun. This policy was to continue, to enable results of blood smear examination to reach the clinicians with minimum delay. Decentralization of the laboratory services continued and a fully functioning Cross Checking Laboratory with 20 microscopists and 2 MLTs, was established in Colombo.

Epidemiological Investigations - In view of the magnitude of the malaria situation, case investigations were to be confined to *P. falciparum* cases, and to some of the vivax malaria cases occurring in the traditionally non-malarious areas. It was to be conducted by senior malaria personnel at the regional level and subsequently to be analyzed at the AMC Head Quarters. During most of the year selective blood smear taking had to be resorted to, because screening of all fever patients was impossible due to the heavy work load, specially on the laboratory.

Active Case Detection (ACD) - 346 personnel were engaged in this activity, however the personnel engaged in ACD had to be sometimes deployed to run Treatment Centres in highly affected localities, and also to supervise spraying units.

Activated Passive Case Detection (APCD) - This activity was carried out in 169 medical institutions.

Passive Case Detection (PCD) - The medical institutions in the malarious areas, beside the 169 activated institutions in which APCD was carried out, were required to carry out passive case detection.

Mass Blood Surveys (MBS) - For obvious reasons, MBS had to be limited to cover only falciparum malaria cases; however, even vivax malaria cases reporting from the traditionally non-malarious areas were covered.

2. Residual insecticide spraying:

To support the extensive residual spraying programme, the Entomological services were to be strengthened. Continued monitoring of the susceptibility levels of *An. culicifacies*, and a survey to determine the distribution and relative densities of *An. culicifacies* in the malarious and the traditionally non-malarious areas in the South-West part of the country, were felt as immediate needs. The number of Entomology teams was increased to 5. Sivagnanasundaram who calculated the Basic Reproduction Rates for the Grama Niladhari areas in the Hiripitiya Vigilance Unit covering 311 villages (1967 population 67,096) in Kurunegala district, for the epidemic period, found the rates to be high, in the region of 50 to 200.

The rapid spread of transmission over majority of the districts required residual spraying on a massive scale, but additional logistic requirements (insecticides, spraying equipment, and manpower) were not readily available, and it was possible to establish the new spraying units only from December 1967. From the 16 spraying units which were functioning at the end of the Last 12-month period (October 1966 to September 1967) the number was increased to 74 (64 Mobile and 10 Walking) by the end July 1968. The situation was considered a national emergency, and assistance from the Army was obtained, by way of personnel, to carry out spraying along river basins in the intermediate zone, viz, Maha Oya, Deduru Oya and the middle reaches of Mahaweli Ganga (along with the tributaries). This step was considered necessary as the vulnerability in the towns and villages in the areas concerned was likely to increase, with

infected migrants returning from the dry zone.

In a part of the affected parts of the Central Province, BHC (50% wdp) was used for residual spraying, as an emergency measure to overcome the DDT shortage created by to the explosive epidemic. The target dosage was 0.4g of Gamma Isomer of BHC per m². Although the Anti Malaria Campaign uses Hand Compression Type sprayers for residual spraying, the emergency condition required even the addition of Knapsack Type sprayers, which could be locally purchased. This type of sprayers is generally meant for use in agriculture-related spraying, and is not quite satisfactory for residual spraying in a malaria programme.

Perennial spraying - A population of 4 million in the hyperendemic dry zone were to be protected with 2 rounds of spraying (DDT 1 Gm / sq.mt) at an interval of 2 to 2½ months. The two rounds were to be completed before end of December 1968.

Focal spraying - 1 million population living in the intermediate zone were to be protected with focal spraying, as and when necessary.

Implementation of the Emergency Programme

The resources of the anti malaria campaign had been stretched to the limits, handling a countrywide epidemic of quite an explosive nature. Obviously the manpower and supplies required to launch the emergency plan could not be made available within a few weeks. However by end of October 1968 the programme was implemented in full, and more or less broadly completed by the end of July 1969. The residual spraying envisaged in the first stage was completed by June 1969 (perennial spraying in 46 health areas of the dry & intermediate zones). Eventually the population covered by this activity was 0.5 million more than the population for which the activity was recommended in the emergency plan.

A notable administrative change was effected in the administrative pattern which was operative for nearly 20 years, and Medical Officers of Health were given administrative control of all personnel engaged in anti malaria activities within their respective health areas, along with the responsibility for the malaria control activities. However, the Regional Malaria Officers continued to be under the administration of the Superintendent of the Anti Malaria Campaign, and more so, the conduct of the anti malaria programme remained vested with

the Superintendent of the campaign, through his Head Quarters staff and the Regional officers.

Mortality during the epidemic

The extremely low mortality rate during the 12-month period was a great relief. Investigation of 37 cases, out of the total of 57 reported as deaths due to malaria, revealed that only 12 deaths could be confirmed as due to malaria, as per the accepted definition of a malaria death (10 from vivax malaria, 2 from falciparum malaria). Another 13 deaths were assumed to be due to malaria, but unfortunately results of blood smear examination were not available actually from malaria. The actual number of malaria deaths during the 12-month period was assumed to be less than 50 (a rate of less than 4 per million population). Reasons for this extremely low mortality, in spite of a very high morbidity in a population lacking in acquired immunity due to the long malaria-free period preceding the epidemic, were thought to be due to the fact that the epidemic was almost exclusively one of vivax malaria, and the ready availability of antimalarial drugs to the patients (both in medical institutions and with the field staff of the malaria program).

Impact of the Emergency Programme

As mentioned earlier, the implementation had to be delayed for inevitable reasons, and therefore the Dec 1968/ Jan1969 peak and the Dec 1969 / Jan 1970 peaks could not be prevented. But the effects of the control measures eventually surfaced, and the total country incidence in 1971 was 68.9 % less than that of the previous year. However a disturbing fact was noticed, in that although the vivax incidence was drastically reduced, the proportion of falciparum malaria was now significant, viz., 2.5% of the total (3711 cases)

Causes for the Epidemic

In the year1963, Sri Lanka was in quite an envious position, drawing global complements for its successful completion of the attack phase, and eradication seemed so near. Therefore when the resurgence took place early in the consolidation phase, culminating in a countrywide epidemic, many analyses were made and views expressed internationally, as to the possible causes for the failure of the eradication attempt.

The WHO Team who came to assist the national malaria authorities, at the invitation of the government, identified in their report, four clear causes which they concluded played a dominant role:

1. Persistence of pre-epidemic foci of infection
2. Abnormal climatic conditions
3. Population instability
4. A population susceptible to malaria

1. Pre-epidemic foci of infection -

Judging from the sequence of events connected to the appearance of vivax foci during the early consolidation phase, it might be quite reasonable to conclude that low-grade active transmission had persisted in areas which had high malariogenic potential in the past, even after the cessation of attack phase. Following the focal outbreaks in the chena settlements in Kurunegala and Matale Health Divisions, in early 1967, Anti Malaria Campaign investigations revealed that there were several persons coming from the wet and intermediate zones, into these chena settlements. The possibility of these migrants introducing malaria to the chena settlements was considered because of the chances that low-grade malaria transmission could have been easily missed in the wet and the intermediate zones, as there was no effective case detection machinery to cover these climatic zones. In any case it originated from a deficiency in the surveillance mechanism, the effects of which manifest itself when residual insecticide cover was withdrawn.

In the consolidation phase of a malaria eradication programme, the vector density would definitely reach a critical level during the second and third years of the phase due to the lack of insecticide coverage. Therefore any imported case from within or outside the country, into a vector infested area would result in a potential malaria focus, which if undetected for any length of time, may produce new or residual active foci, with secondary malaria cases due to fresh local infection.

Gabaldon a Malariologist who visited the country in 1966, commenting on the rapid spread of malaria foci in the country, describes a village (Pahariya) with 258 inhabitants, with a camp located near the village. The camp belonged to a contractor carrying out land development work, and in the camp there were workers from many villages. Although Pahariya village received regular monthly visits from the malaria surveillance agent (ACD agent) in the year 1965, all the blood smears taken (including in November and December 1965) were found to be negative. However in a hospital 15 miles away from the village, 2 blood smears taken on 17th January 1966 were found to be positive for *P. malariae*, and by the 10th of February, a total of 50 positive cases were detected among the inmates of the village. Subsequent investigation of the focus revealed that

from Pahariya village and from the neighbouring contractor's camp people had moved to 58 different villages (some of them more than 20 miles away). Eight of these villages had imported malaria infections from Pahariya.

2. Abnormal climatic conditions -

The WHO team who compared the total rainfall offsets from 17 representative stations in the country, obtained from the Colombo Observatory during the period of September to June of 1934/35 and 1967/68. They concluded that the rainfall pattern in the intermediate and the dry zone, for 1934/35 and 1967/68 correspond very closely, and the dry period in 1967/68 was mid December 67 to end of February 1968, as compared to the dry period in 1934/35, which was from mid October to 1934 to end of January 1935. They found the rainfall pattern in all districts which had a high intensity of malaria during the epidemic, were similar, especially between December 1967 and May 1968, rainfall being abnormally low in February 1968.

Commenting on the relationship between rainfall and malaria, Gill stated that in Ceylon, epidemics in the wet zone are the result of drought, whereas in the dry zone excessive rain is the determining factor for epidemics. However the WHO team was of the view that the relationship is more complex, and that in the river basins there will be a range of rainfall between a level just sufficient to cause formation of pools in the dry bed and an upper level which just fails to maintain flow over the whole channel. Within these levels *An. culicifacies* production can be expected. This range will differ according to peculiarities of the upper catchment areas and lower reaches of river valleys. Why then during the 1934/35 epidemic, extent of the involvement was limited to the wet and the intermediate zones, if the rainfall pattern was similar? It is explained by the fact that herd immunity against malaria, resulting from continuous exposure to malaria in the pre-DDT era, protected the dry zone population during that epidemic.

3. Population instability –

“Diffusibility” has been defined by Gabaldon as the number of localities infected from a single focus, which are the functions of vector and its ecological conditions and of man and his social habits respectively, parasite playing the same role in both cases. The WHO team was of the opinion that the population movements that took place in the country, had resulted in enhanced diffusibility,

and was an important factor in the spread of the epidemic. Both the long-range movements and the short-range movements increased after 1965, following the discovery of gems at Elahera, and the Food Production Drive which had been launched. The short-range movements comprised travel associated with youth camps and land development schemes. The long-range movements at the time mostly included persons traveling to the Elahera gemming sites from various districts in the country, and also pilgrims visiting the traditional religious centres, most of which are in the dry zone. In fact, the creation of the minor epidemic centre in Kataragama, was attributed to the introduction of infection by persons from Elahera gemming centre who visited Kataragama. Latter area had become highly vulnerable at the time due to pooling of Menik Ganga. The good network of roads, and the fairly good public transport system available at the time at a comparatively low cost, very much facilitated internal travel.

4. Population susceptible to malaria –

A remarkable observation made on the 1934/35 epidemic, is its limited spread within the country, in spite of its virulent nature. In general, the areas which had been labeled hyper-endemic at the time were spared. In the pre-DDT era the country population, especially in the dry zone, was constantly exposed to malaria, and it would be quite reasonable to assume therefore, that they possessed a high degree of acquired immunity against malaria, which would have protected them against the disease. Following the introduction of DDT spraying programme in 1946, the picture changed. There was a drastic reduction in the malaria incidence in the formerly malarious areas, which was reduced even more, by the launching of the eradication programme in late 1958. During the period 1958 to 1966 the annual parasite incidence was less than 0.01 per 1000. When the malaria transmission increased rapidly at the commencement of the epidemic, it was faced by a population with adults who had more or less lost whatever acquired immunity they had against malaria, and by children who perhaps never had encountered a single episode of malaria.

Bruce-Chwatt, commenting on the set back faced by the Eradication programme, launched by Sri Lanka, mentions some additional causes which attributed to the failure:

- inadequate geographical reconnaissance
- surveillance data pooled in such a way that persistent smaller foci were not spotted in time
- premature cessation of total coverage with spraying

- delayed remedial measures due to inadequate supervision
- shortcomings of epidemiological evaluation and radical cure
- much higher vectorial capacity of the Ceylon strain of *An. culicifacies*.

Gabaldon was of the view that in highly endemic zones in the tropics, or in areas with a great transmission potential and continuously exposed to imported malaria cases, indoor residual spraying should not cease with the commencement of the consolidation phase in an eradication programme. He recommends maintenance of spraying during the 3 – year period after the last indigenous case, and is of the opinion that active case during this period is used only as an evaluation activity and not for the elimination of residual cases.

Abeyesundere analyzing the causes for the resurgence of malaria in Sri Lanka in 1964, following the failure of the eradication programme, adds the following contributory factors:

- insufficient surveillance coverage
- inexperience and lack of orientation of medical and para-medical personnel serving at the time, with regard to the necessity of screening fever patients for malaria, and the possibility of the rapid spread of the disease (many of the younger medical officers and para-medical personnel had no experience in diagnosing and handling malaria patients, because of the extremely low malaria incidence during the preceding years)
- Work attitude of the casual workers
- inadequacy of laboratory services
- lack of sufficient inter-agency and inter- departmental coordination

Did vector resistance against DDT play a part in the epidemic?

In scientific literature concerning the genesis of the 1967/69 malaria epidemic in Sri Lanka, a part played by vector resistance to DDT, has sometimes been mentioned. The insecticide susceptibility tests carried out by the anti malaria campaign revealed first signs of DDT resistance in *An. culicifacies*, only in 1969. Eight out of fifteen tests which were carried out mostly during the early part of the fiscal year Oct. 1969 to Sept. 1970 indicated an intermediate stage of resistance, while seven out of the fifteen tests carried out mostly during the

late part of the fiscal year indicated advanced resistance. During this fiscal year period DDT resistance was confirmed during tests done in a location at Uduwela in Hambantota district. Therefore the facts indicate that DDT resistance in the vector played no part in the genesis of the epidemic, and its extensive and explosive spread in the early part. Vector resistance would have certainly contributed to the persistence of a high level of transmission in the subsequent period witnessed, even after the waning of the epidemic.

The climax of the Epidemic and its waning

Although the increasing transmission was evident by the end of 1967, the explosive epidemic commenced only in January 1968. The countrywide incidence reached a climax in the month of February 1968, although district-wise variations were observed. Thereafter a downward trend was observed but a second peak very closely following the first peak in magnitude, followed in December 1968/ January 1969. The June/July 1969 peak was even higher than the preceding Dec/Jan peak, and there was a downward trend from around April 1969, but again the monthly incidence rose reaching a climax in December 1969, surpassing all the previous peaks during this epidemic. Subsequent to the December 1969/ January 1970 peak transmission period, incidence was more or less stable until August 1970 when there was a significant reduction. During the December 70/ January 1971 period the traditional peak was not observed, instead there were substantial reductions during the months of January and February 1971 respectively. A peak was not observed during December 71/ January 1972 period too, and the monthly incidence seemed to have more or less stabilized, with minor monthly fluctuations. It is quite possible that the peaks which followed the initial peak were due to relapsing vivax malaria infections, considering the fact that the epidemic was preponderantly a vivax epidemic, and the drug regimen for vivax malaria had to be changed to a 5-day course, in January 1968, due to operational reasons.

Spatial distribution

A remarkable feature was that unlike in most of the previous epidemics (including the massive 1934/35 epidemic), the epidemic engulfed the entire traditionally malarious parts of the country. The most plausible explanation is that the populations living in the traditional malarious areas have had an unusually long period of malaria-free years, following the successful malaria control which had been achieved after the introduction of DDT spraying. In fact, most of the children and certainly those under 5 years of age, probably would not have been exposed to malaria at all, in contrast to the past when

malaria epidemics were recurring every 3 to 5 years or so. Therefore it is very reasonable to conclude that the lack of any acquired immunity against malaria in the population at the time was a main contributory factor for the rapid and extensive dissemination of the infection during the 1968/69 epidemic. Previous epidemics had been generally confined to the intermediate and wet zones of the country, which were either traditionally non-malarious areas or areas with unstable type malaria.

The problem of acute Intravenous Haemolysis (IVH) following Primaquine in G-6-P-deficient patients

In the early months of 1968, the Paediatrician at General Hospital, Anuradhapura, noticed that several children were passing blood in the urine, following antimalarial drugs. Anuradhapura district had the highest district-wise intensity of malaria transmission at the time, and amodiaquine and primaquine were extensively used. She suspected that the IVH was caused by the existence of a G-6-PD deficient trait in the local population, with the resulting sensitivity of their red cells, to primaquine, and her pioneering work published in the Ceylon Medical Journal revealed for the first time in Sri Lanka, the association between administration of primaquine and the occurrence of IVH in G-6-PD individuals. Abeyaratne proceeded to investigate the incidence of G-6-PD deficiency in the general population. An association between the incidence of G-6-PD deficiency in populations, and their exposure to falciparum malaria in the past has been established, with the postulation that this deficiency in the red cells confers some degree of immunity against falciparum malaria. Therefore G-6-PD deficiency is assumed to have a selective advantage in falciparum malaria. The results of the survey were published by Abeyaratne et al in 1976.

Table 9: Incidence of G-6-P-Deficiency among males in Ceylon (results of field screening by micromethaemoglobin reduction test)

Localities where samples were collected	No. tested	No. positive
Sinhalese purana villages	252	37 (14.68%)
Colonies (Sinhalese ethnicity) Schools	222	8 (3.6%)
- Sinhalese	153	8 (5.2%)
- Tamil	160	0
- Moor	120	6 (5%)
Hospitals	132	7 (5.3%)
- Sinhalese		

Results clearly showed that the incidence of the enzyme deficiency was much higher in the populations in ancient villages, as compared to that among the populations living in recently colonized areas, supporting the theory that the distribution of the deficient populations has a relation to past exposure to falciparum malaria.

The findings had a profound beneficial effect. The clinicians serving in the North Central Province were alerted so that remedial measures could be taken at the earliest signs indicating possible sensitivity in patients treated with primaquine. Patients diagnosed microscopically as infected with falciparum malaria were prescribed only 3 days of primaquine (for the gametocytocidal effect) as against the former regimen of 14 days. Malaria patients with any evidence to suspect the enzyme deficiency (eg. history suggestive of any degree of IVH after primaquine) were not prescribed primaquine at all. At the time repeated attacks of malaria were very common, and obtaining a history for any possible symptoms of IVH following administration of antimalarial drugs for previous attacks, was very useful.

Demarcation of the country into “epidemiologically homogeneous zones”

Dr. D.G Pradhan, the WHO Malariologist serving in Sri Lanka at the time, analyzing the data pertaining to the 1967/69 epidemic noticed that different health areas had displayed different well-defined courses during the rise and the fall of the epidemic. He was of the opinion that the local malariogenic potential of different areas, was also a determining factor influencing the trend of malaria incidence during the epidemic, in addition to the effect of the control measures implemented. He described 6 demarcations, which he referred to as “epidemiologically homogeneous zones:

1. Jaffna Peninsula - Majority of settled villages
2. Eastern Coastal Belt - More settled villages, comparatively good agricultural development
3. Northern Dry Zone - Settled villages with a number of chenas and a pronounced network of tanks
4. Eastern Foot Hill - Less settled villages, a large number of chenas, river fed areas with jungles and large development projects

- 5. Intermediate Zone - Heavy rainfall. In case of droughts, subjected to epidemics
- 6. Wet Zone - Heavy rainfall and more urbanized areas. Subjected to epidemics in drought conditions

For malaria epidemiological studies the country was already divided into 3 climatic zones, based on the total rainfall received during the south west monsoon:

- 1. Wet Zone - rain fall > than 1000 mm
- 2. Intermediate Zone - rain fall between 500 – 1000 mm
- 3. Dry Zone - rain fall less than 500 mm

In the suggested new division into 6 zones, the Intermediate and the Wet zones were roughly corresponding to the corresponding climatic zones, but the Dry zone of the previous climatic division had been subdivided into the Peninsular, Northern Dry, Eastern Coastal and Eastern Foot Hill Zones.

Receptivity, Vulnerability and the Malariogenic Potential - Pradhan calculated these indices for the pre-DDT era, based on the spleen rates and parasite rates obtained for the years before 1946, and also for the years 1971/72, and based on the vectorial capacity values compiled by the AMC Entomology Division. His estimates are tabulated in Table 11. It was observed that in the Eastern Foot Hills zone the decline of the epidemic was extremely sluggish, and that *P. falciparum* cases in 1969 were very significantly (82.2%) detected in this zone.

Based on the malariogenic potential calculated, Pradhan recommended that in the later phases of malaria eradication, the Northern Dry Zone, Eastern Foot Hills Zone and the Intermediate Zone be placed under permanent vigilance. It was observed that the malariogenic potential in the Intermediate Zone had increased at the time the new demarcation was worked out.

Table 8: Malariogenic potential calculated for the “Epidemiological zones”

Zones		Pre-DDT Era			1971/1972	
Receptivity	Receptivity	Vulnerability	Malariogenic potential	Receptivity	Vulnerability	Malariogenic potential
Jaffna Peninsula	2	1	Low	-	-	-
Eastern Coastal Belt	3	3	High	3	3	Low
Northern Dry Zone	4	3	Very high	4	3	Very high
Eastern Foot Hill	4	3		5	3	Very high
Intermediate Zone	2	2	Medium	4	2	Very high
Wet Zone	1	1	Low	-	-	-

Post Epidemic Period – 1971 - 1982

By 1971 the epidemic curve declined, but the annual parasite incidence for the years 1971 and 1972 was much higher than that prevailed in 1967, prior to the epidemic – Figure 7.

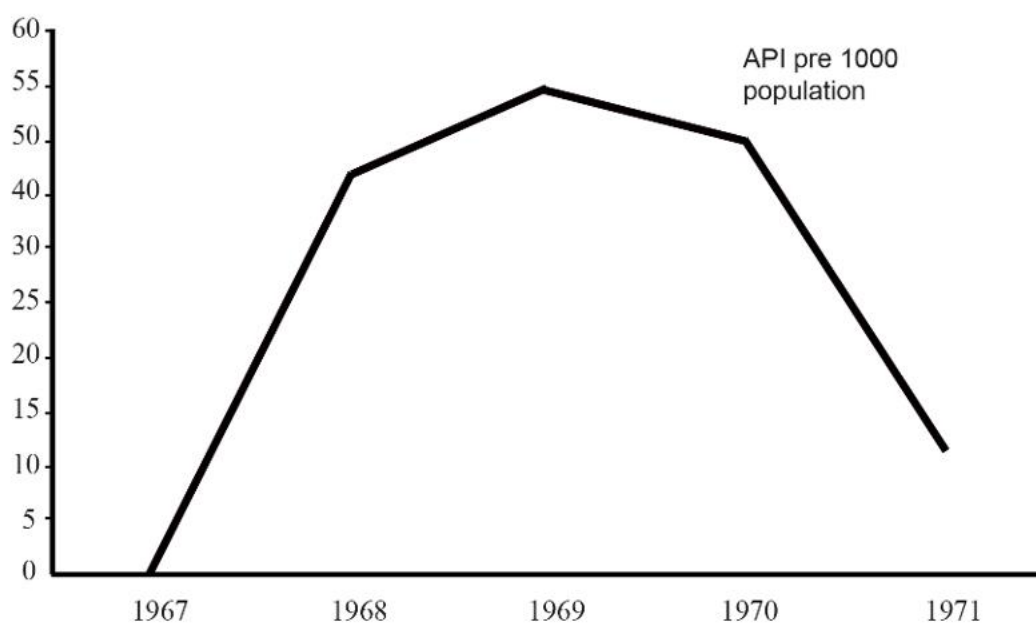


Figure 7 – Annual Parasite Incidence (API) - 1967 – 1971

Increase in *P. falciparum* transmission

In 1969, the number of *P. falciparum* cases detected in the country, revealed a more than a 10-fold increase compared to the number detected 1958, the year of commencement of the eradication programme. Thereafter there was an alarming increase between the period 1973 and 1975, the falciparum percentage reaching up to 15.9%. *P. falciparum* infections which have been earlier confined to traditional falciparum foci such as health areas of Bibile and Moneragala, were now then encountered in health areas of Wariyapola, Maho, Galgamuwa, Kekirawa, Anuradhapura, Kahatagasdigiliya, Puttalam and Trincomalee.

Table 10: Annual *P. falciparum* incidence in the health divisions – 1973 – 1975

Health division	Percentage of <i>P. falciparum</i> infection		
	1973	1974	1975
Anuradhapura	0.1	10.3	36.0
Puttalam	0.1	2.7	16.1
Kurunegala	0.04	0.8	3.6
Matale	0.8	3.1	10.0
Batticaloa	1.1	3.0	5.6
Badulla	6.5	13.4	13.0
Source – Anti Malaria Campaign			

Development of vector resistance to DDT

Development of malaria vector resistance against D.D.T in several malarious countries world over was a major factor that prompted the other malarious countries to adopt strategies to eliminate transmission of malaria within their territories. Although not among the very first countries to get affected, Sri Lanka too eventually had to face the inevitable. DDT resistance in *An. Culicifacies* was first detected during entomological investigations in 1969. The resistance was observed to spread gradually in the vector populations in the country. By 1974 the presence of DDT resistance was observed in all vector populations. This however, was not the only contributory cause for the increasing transmission. Following DDT spraying over a period of over two decades, an element of householder resistance towards indoor residual spraying too resulted in poor coverage in time and space. These two factors together contributed in a very big way towards the high transmission levels maintained, specially with regard to *P. falciparum*.

The Anti Malaria Campaign wanted to make an assessment whether the degree of vector resistance that had developed would constitute an operational problem for transmission reduction. A decision was made to carryout residual spraying under very strict supervision in a selected trial area, with proper coverage in time and space ensured, and to assess the impact on malaria transmission.

This study area was selected in the village of Tonigala in health area Puttalam (northern dry belt). Initially 265 structures were present, with a population of 11,800. Four rounds of DDT were sprayed (1g/m²) during the period October 1973 to March 1975. An Independent Evaluation Team comprising the Chief Epidemiologist of the Ministry of Health, Sri Lanka, The Senior Medical Officer of the Malaria Division, Vector-Borne-Diseases Division of the WHO Head Quarters, Regional Entomologist of the WHO/SEARO, Chief of the USAID Health Section, and a representative from the Ministry of Planning, Sri Lanka, carried out a Situation Analysis of the Anti Malaria Programme in Sri Lanka, in February 1976. It was at the request of the Government of Sri Lanka, in view of the sharp rise in the falciparum malaria incidence. The Anti Malaria Campaign was considering changing the residual insecticide that was in use (DDT), and also the introduction of supplementary methods of vector control. The team, in their report, summarized the findings of the special trial done in Tonigala area.

In their conclusions and recommendations, the Team emphasized on the following:

- The main reasons for the lack of improvement in the country malaria situation during the last few years, inspite of concentrated efforts, are the vector resistance against DDT, and the operational and administrative shortcomings.
- An intensive malaria control programme should commence as soon as possible.
- The main control strategy should be indoor residual spraying with malathion, however transmission should be interrupted within the shortest possible time, in view of the possibility of vector resistance developing.
- The coordination between the Anti Malaria Campaign and the general health services should improve, and the lines of command must be well defined.
- To further carry out assessment of the efficacy of malathion in the interruption of transmission until March 1977, in view of the likely delay in rewamping the coordination processes.

- To ban the use of malathion and the possible alternative candidate insecticide, fenitrothion, for any other use than for malaria control in Sri Lanka, so that their potential value as a main tool in malaria control in the country, could be maintained as long as possible.

Total withdrawal of DDT spraying

The Anti Malaria Campaign was getting ready for the use of the alternative residual insecticide, malathion. Considering the extremely large number of houses which had to be included under perennial spraying, total change of the residual insecticide was no easy task. The spraying with malathion was to be repeated at 3-monthly intervals. The insecticide being an organophosphate, more stringent safety precautions for the spraying unit personnel had to be planned, including carrying out the estimation of cholinesterase level of persons, regularly at 3-monthly intervals. For the latter purpose a colorimetric method which could be performed in the field, was to be used. All spraying unit personnel and the supervising officers had to be re-orientated.

Meanwhile the DDT resistance in the vector was spreading. The susceptibility tests carried out in Moneragala, Kirindiwela and Chilaw Medical Officer of Health areas on *An. culicifacies*, during the year 1976, revealed that exposure to DDT 4% concentration revealed resistance in all the localities.

Efficacy of malathion as the alternative residual insecticide

Starting from April 1975, the effectiveness of malathion in interruption of transmission was field-tested in Tonigala, a village in Puttalam health area. 3240 houses were sprayed with malathion, at the target dosage of 2 g per m², spray cycles being repeated at 3-monthly intervals. The entomological and epidemiological assessment made by the Anti Malaria Campaign revealed that malathion was successful in reducing malaria transmission effectively. These findings were supplemented by the results of sero-epidemiological studies carried out independently by the WHO Parasitologist serving in Sri Lanka at the time (Dr. B. Bisseru), and by the Prof. T. Ponnudurai, Prof. of Parasitology of the Faculty of Medicine, University of Colombo. Their investigations showed that the titre of malaria antibody level in all age-groups of the population living in the area protected by malathion spraying, had declined

remarkably over the year in which malathion was sprayed, compared to the titres in the population who lived in the area which did not receive malathion protection.

The susceptibility tests carried out by the Anti Malaria Campaign in June – December 1976 at different health areas (Polgahawela, Moneragala, Mirigama, Kirindiwela, Hamabantota, Chilaw, Kahatagasdigiliya, Mannar and Puttalam) exposing *An. culicifacies* to the test dose of 5.0% malathion (for 60 minutes), revealed 100% mortality.

The Anti Malaria Campaign was making preparations for the launching of an intensive malaria control programme in 1977. Personnel of those spraying units which had temporarily suspended work following the withdrawal of DDT from the indoor residual spraying programme, and waiting for the countrywide malathion spraying programme to commence, were gainfully engaged in updating the geographical reconnaissance. This was very necessary as it had been decided to introduce alternative vector control methods too. Additionally, these spraying teams were also engaged to carry out larval surveys, and intensified case detection and treatment in the field.

Commencement of malathion spraying

A landmark event in the history of malaria control was witnessed, in that, Sri Lanka, the first country in Asia to introduce large scale DDT spraying for malaria control, totally abandoned usage of DDT for malaria control by the end of July 1976, after a lapse of 30 years. Replacement of DDT spraying with malathion spraying, did not take place in all health areas simultaneously. In view of the great urgency to control intense *falciparum* transmission, a 'crash programme' was launched in March 1975, by introducing residual spraying with malathion in the health areas of Bibile, Moneragala, and also in the adjacent parts belonging to the health areas of Balangoda, Atakalampanna. The target dosage was 2g/m². Malathion 50% water dispersible powder (WDP) was the formulation used, suspended in water. 3-monthly spray cycles were maintained. Pending subsequent introduction of malathion, the health areas of Kekirawa, Anuradhapura, Kahatagasdigiliya, Trincomalee, and portions of health areas of Hambantota, Walasmulla, Tangalle, Batticaloa, Valachchena, Tirukkivil, Ampara and Rattota, were sprayed with a higher target dosage of DDT

(2g/m²) at the frequency of 4-monthly intervals. Later, in September 1975, malathion spraying was extended to the health areas of Puttalam, Kekirawa, Anuradhapura, Kahatagasdigiliya, and Tricomalie. Again in November 1976, health areas of Maho, Galgamuwa, and Naula too were placed under malathion spraying, replacing DDT. In the health areas of Gokerella, Dambulla, Vavuniya and Kilinochchi too, DDT spraying was replaced with malathion spraying, but on a focal basis.

Measures implemented to delay the possible emergence of vector resistance against malathion

Having had to abandon the use of DDT after the vector populations developed resistance, it was of paramount importance to take whatever steps possible to delay as much as possible, the emergence of vector resistance to the alternative insecticide introduced. At the time malathion formulations were been freely used in Sri Lanka, in the agricultural sector as a pesticide. The technical opinion was that it would be most appropriate to ban the use of malathion in agriculture once this insecticide is introduced for malaria control. In April 1976, a very important decision which had far reaching effects, was taken at a high powered meeting attended by the Ministers of Health and Agriculture, and top officials from the two ministries, including the Superintendent and the Entomologist of the Anti Malaria Campaign. It was decided that the import of malathion for agricultural purposes be prohibited with immediate effect, and also that the use of fenitrothion formulations in agriculture be banned after the 'yala' season of 1977. Fenitrothion was the alternative insecticide the Anti Malaria Campaign had decided on, if malathion resistance were eventually develop in the vector populations. The decision on prohibition of the use of malathion, for any other purpose except in malaria control in Sri Lanka, was given legal status, by an Act of Parliament.

Localized epidemics in the wet zone (May/June 1976)

The year 1976 revealed a drastic drop in falciparum malaria cases compared to the preceding year (approximately by 70%), and also a significant decline in vivax malaria cases. Unfortunately the wet zone was affected by failure of the South West Monsoon, resulting in pool formation in rivers such as Maha Oya, Deduru Oya and Aattanagalu Oya, leading to localized malaria outbreaks. These outbreaks

were controlled by focal spraying with malathion, and intensified case detection and treatment.

The Intensive Malaria Control Programme 1977 to 1982 -

The Independent Evaluation Team which reviewed the malaria programme, in 1976, had subsequent discussions with the national health authorities including the Anti Malaria Campaign authorities. It was observed that each year, during the years of 1973 to 1975, more than 8% of the total health budget of Sri Lanka, was spent on malaria control to which the government was committed. However, due to a multitude of reasons, both technical and non-technical, the country malaria situation was not improving. Realizing the need to interrupt malaria transmission in the country within the shortest possible time period, the Anti Malaria Campaign authorities, in consultation with the Evaluation Team members, prepared a draft Plan of Operation for a 5-year Intensive Malaria Control Programme. The estimated cost for each of the first 3 years was Rs. 86.0 million, approximately 75% of the annual cost being the funds required to purchase residual insecticides and spraying equipment. The government was willing to bear the cost of all recurrent expenditure and a part of the capital cost. It was felt that the proposed programme would obviously be accelerated if foreign assistance was available for the purchase of the residual insecticide.

Foreign assistance was granted by several countries, the bulk portion coming from the Government of United States, through The United States Agency for International Development (USAID). In fact, a Public Health Expert from the USAID was stationed in Sri Lanka in due course, to monitor the programme, with emphasis on the safety aspects of malathion use in the field.

The main activities under the Intensive Malaria Control Programme

1. Indoor residual spraying
2. Introduction of supplementary methods of vector control
3. Case Detection & Treatment
4. Epidemiological investigation of malaria cases
5. Laboratory services

- 6. Entomological studies
- 7. Health Education activities
- 8. Training activities

1. Indoor Residual insecticide spraying (at a target dosage of 2g Malathion/m²)

A total population of 4,276,100 living in areas in which risk of malaria transmission existed at the time, were to be protected with malathion spraying.

Degree of endemicity in the area of spray activity	No of houses	No. of spray applications during year
Hyper-endemic	799,512	4
Meso-endemic	34,900	2
Hypo-endemic	36,450	2
Total No. of Houses		- 870,862
No. of health areas for 4 applications / year		- 32
No. of health areas for 2 applications/year		- 19

All human dwellings, outer houses and animal shelters, in the built up areas, and all temporary structures such as those found in chena settlements, land development projects, forest camps, and gemming sites, in other areas, were to be included in the spraying programme. It was decided that 428 Walking Units and 86 Mobile Units would be required for the spraying programme under the intensive programme.

2. Introduction of supplementary methods of vector control

Since the commencement of the countrywide residual spraying programme with DDT, it was practically the sole method of vector control carried out by the Anti Malaria Campaign. With the launching of the intensive malaria control programme, it was decided that whatever supplementary vector control methods practiced at the time, be implemented.

Chemical larviciding, using Temephos Emulsion Concentrate (500 EC) at a dilution

of 100g/hectare, was carried out in rivers/streams, during periods of pool formation, after ascertaining the presence of vector breeding, by entomological investigations. Usually this state of affairs in rivers and streams is observed during the period June to September. The cost-benefit aspect was taken into consideration, taking into account how far the human dwellings were from the rivers/streams considered for larviciding, and whether such dwellings were grouped together or widely scattered.

A four kilo metre long stretch of Menik Ganga (Kataragama town to Sella Kataragama) flows through a populated area. During dry weather which usually coincides with the Kataragama Annual Festival, drawing very large crowds, this stretch of the river was regularly subjected to larviciding. Kirindi Oya in Lunugamwehera project area, and water bodies around Madhu Festival area, were other target sites for regular chemical larviciding during the appropriate months.

Flushing of breeding sites in irrigation canals - Following the construction of the dam across Mahaweli Ganga, at Polgolla site, an increase of malaria cases in localities on the banks the river downstream, was observed during dry months. This was observed over a distance of about 9 miles beyond the dam site. During the two trials the carried out in collaboration with the Mahaweli Development Board, it was revealed that the weekly release of 2000m³ of water downstream over a 3 hour period through the release gates of the dam, would flush out the breeding sites, and would significantly reduce malaria vector breeding in the river beyond the dam site. However, during dry months, Mahaweli Delopment Board officers were faced with the problem of having to conserve the maximum amount of water for generation of hydro-electricity. Therefore this procedure could not be made operational.

3. Case Detection & Treatment

- In Malaria-endemic areas - blood smear was taken from all fever patients attending the out patients' department of medical institutions in malaria-endemic areas, and sent for examination.
- Traditionally non-malarious areas - blood smear was taken from those having clinical features of malaria, or those suspected of being infected with malaria, for any other reason (eg history of travel to a malarious area).

- Activating Medical Institutions - to facilitate the process, the medical institutions in the endemic areas, in which the daily fever attendance was high, were provided with Field Assistants (now designated Public Health Field Officers) from the Anti Malaria Campaign (APCD agents). Taking blood smears at the remaining medical institutions in endemic areas was to be accomplished with the assistance of the personnel of the general health services attached to such institutions.

- In the field - Beginning from the second year of the intensive programme, a population of approximately 8 million were to be covered with active case detection. Active case detection was to commence in the hypo-endemic areas, but was to be extended to all areas in which malaria would be endemic, as the Annual Parasite Incidence reaches less than 1 per 1000. Field Assistants of the Anti Malaria Campaign were appointed in due course as ACD agents, to carry out active case detection by house visiting at regular intervals, on a pre-arranged programme. Each agent was expected to visit on an average, 50 houses per day. They would take a blood smear from any householder having fever at the time of his visit, or who have had fever during any time since his last visit to the house. During these visits, anti-malarial drugs would be given to those suspected of having malaria, and the ACD agent would also take the opportunity to impart health education on the householders. Additionally, if the ACD agent was working in an area under residual spray coverage, he would inquire about houses which escaped insecticide spraying, and pass on the information to the spraying team who work in the area. Public Health Inspector (PHI-Vigilance Unit) was responsible for the supervision of ACD and APCD agents, and the spraying units. He was provided with a jeep and a driver for his official work. He had to take a sprayman along with him during his field rounds, to carry out mop-up spraying, on the detection of any unsprayed dwelling. He would also coordinate mass blood surveys and mass radical treatment programmes, as and when necessary, and carry out health education activities during his field visits.

4. Epidemiological investigation of cases -

It was envisaged that by the 3rd year of the intensive programme, the case load would come down to a manageable level, to permit case investigations. The Regional

Medical Officers, Public Health Inspectors of the Anti Malaria Campaign attached to the Regional Offices (PHI/ AMC) and the PHI s attached to the MOH offices, but engaged in full-time malaria control activities (PHI-Vigilance Unit), were assigned this activity. The Medical Officers of Health (MOH) were expected to assist in this process, whenever possible.

5. Laboratory Services

About 2 million blood smears per year were expected for microscopic examination during the intensive programme. The following staff was in position in the network of Anti Malaria Campaign laboratories in the country (Central Laboratory and the Cross Checking Laboratory in Colombo, and 7 Regional Laboratories).

Laboratory category		Staff category
	Medical Laboratory Technicians	Microscopists
Central	2	45
Cross-checking Lab	2	50
Regional Labs (7)	7	120

The cross checking laboratory would re-examine 10% of the total number of blood smears examined annually by all the laboratories carrying out the first examination. These smears for re-examination were to be selected at random.

6. Entomological Studies

The 2 Entomologists of the Anti Malaria Campaign would direct the entomological studies, under the overall direction of the Head of the Campaign. Twelve Entomology Teams were to function, each with an Entomological Assistant, 2 Field Assistants, and 4 Labourers. Each team would be also provided with a vehicle and the driver. Routine entomological investigations would include insecticide susceptibility studies, bio-assay tests, man-biting rates, parous rates, indoor resting densities and exit window trap observations, among others. Studies related to chemical larviciding,

and the use of larvivorous fish, were also to be carried out with view to expand the use of supplementary methods of vector control.

7. Health Education Activities

Malaria control personnel at all levels were to carry out health education activities during their routine work. The Health Education Unit attached to the AMC head quarters, functioning under the Health Educator, and equipped with a Cinema Van (along with the cinema operator) would coordinate with the Health Education Bureau of the Health Ministry, both at the central and divisional levels, to implement health education programmes relevant to malaria control..

8. Training Activities

The Training Centre of the Anti Malaria Campaign which was located at Deans Road, Colombo 10, was in charge of a full time Medical Officer, and a PHI, and was geared to conduct training courses for all category of health staff (including Medical Administrators), and also for Volunteer officers from other services (eg. Army Volunteers).

Administration, Finances & logistics (including transport) support was provided by fully staffed divisions functioned at the Anti Malaria Campaign head quarters, including a fully equipped garage and workshop meant to carry out maintenance work to the country-wide fleet of vehicles belonging to the Anti Malaria Campaign.

The impact of the intensive control programme

After launching of the programme, in which the main strategy was extensive coverage with indoor residual spraying using malathion, results over the subsequent 5 years were spectacular, as seen from the Figure 8.

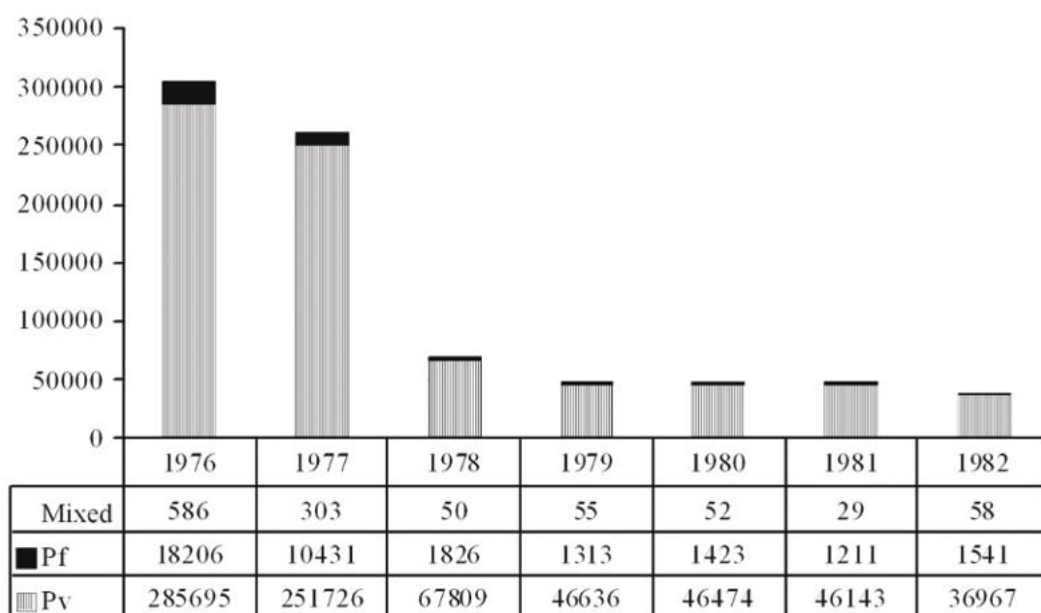


Figure 8 – Malaria incidence before and after the launching of the ‘Intensive Malaria Control Programme’.

Malathion susceptibility levels in *An. culicifacies* after 5 years of use - When tested after a lapse of 5 years following the first introduction of malathion in the residual spraying programme in 1975, population samples of *An. culicifacies* exhibited susceptibility to malathion, in different parts of the country, judging from the results of tests carried out in 21 health areas, during the year 1980.

Stratification of the malarious parts of the country in 1982

At the end of the 5 year intensive programme the total case incidence had declined by 84.4%, with the percentage of falciparum malaria falling to 2.6%. Having suffered one set back caused by the development of DDT resistance in the vector, the Anti Malaria Campaign (AMC) was determined to interrupt malaria transmission within the shortest possible time, and also to take necessary precautions to delay development

of malathion resistance in the vector as much as possible. Insecticide pressure exerted on the vector populations during the preceding 5 year period was very high, and hence a decision was taken to stratify the health areas under regular spray coverage, and continue the IRS programme in a more evidence-based manner. The following factors were considered when grouping the health areas into different strata:

- total malaria incidence during the last 5 years
- falciparum malaria incidence during the last 5 years
- proximity to river basins
- occurrence of any malaria outbreaks during the last 5 years
- presence of any development schemes
- any other special factors that would increase the malariogenic potential of the health area.

The assistance of the Malariologist from WHO/SEARO was also obtained for the exercise. Finality was reached after having discussions with the Regional Medical Officers and the senior Public Health Inspectors who were engaged in full time malaria control duties. At the head quarters level, the Superintendent AMC was assisted by the Epidemiology Unit, Entomology Unit, and the Operations Units, and by the WHO Malariologist and Entomologist who were stationed in Sri Lanka at that time.

The following scheme was adopted for indoor residual spraying, based on the stratification carried out:

<u>Epidemiological zone</u>	<u>Frequency of residual spray applications</u>
Jaffna peninsula	Once a year, preceding the transmission period
Northern dry belt	Twice a year, preceding the transmission period
Eastern Foot hills	Four times a year, preceding the transmission period

In the other epidemiological zones, focal spraying was to be carried out as and when required.

- The period subsequent to the implementation of the residual spraying programme on a stratified basis –
During the year 1982, localized epidemics of *P. falciparum* occurred in the health areas of Anuradhapura, Kahatagasdigiliya, Trincomalie, Vavuniya, Mulativu, Mannar and Bibile.
- Vector susceptibility to malathion in 1982 –
In 1982, *An. culicifacies* remained susceptible to malathion, as reflected by the results of tests carried out. However in certain localities, survivors were found after 30 minutes of exposure to 5% malathion, suggesting whether resistance was emerging. The previous susceptibility tests done in these same localities had revealed that mortality to the discriminating dose was always 100%. However, in these localities 100% mortality was obtained when the exposure time to 5% malathion was extended to 1 hour.
- Failing operational standards of the IRS programme -
Some of the bio-assay results obtained by the Entomology teams indicated that the quality of the residual spraying was not satisfactory in some localities, confirmed by the fact that much higher mortality levels were obtained when residual spraying was done under direct supervision and strictly according to the required technical standards.
- Survey to review the preferred breeding sites of the principal malaria vector in Sri Lanka -
In 1982, the Entomology Division of the Anti Malaria Campaign carried out a very important survey to review the relative importance of the known types of *An. culicifacies* breeding sites in the country, which revealed that the most favoured breeding sites still were the pools of water in dry rivers/streams and irrigation channels.

Table 11: Results of larval collections in different breeding sites - 1982

Type of breeding site	No. of <i>An. culicifacies</i> larvae per dip
Sand pools in river/stream basins	0.02
River margins	0.02
Rock pools	0.09
Irrigation channels	0.07
Paddy fields	0.02
Gem pits	0.01
Rain water pools	0.03
Tanks in villages	0.0009
Earth wells	0.03
Burrow pits	0
Ponds	0.01
Hoof prints & foot prints	0

Important Milestones during 1982 – 1988

During the months of November and December 1982 there was a sharp rise in the case incidence, the total of the positive cases for the two months, representing more than a third of the annual total, namely 34.4%. This was much more than rise expected of a traditional end of the year peak. During the year the many health areas recorded a high incidence – Figure 9.

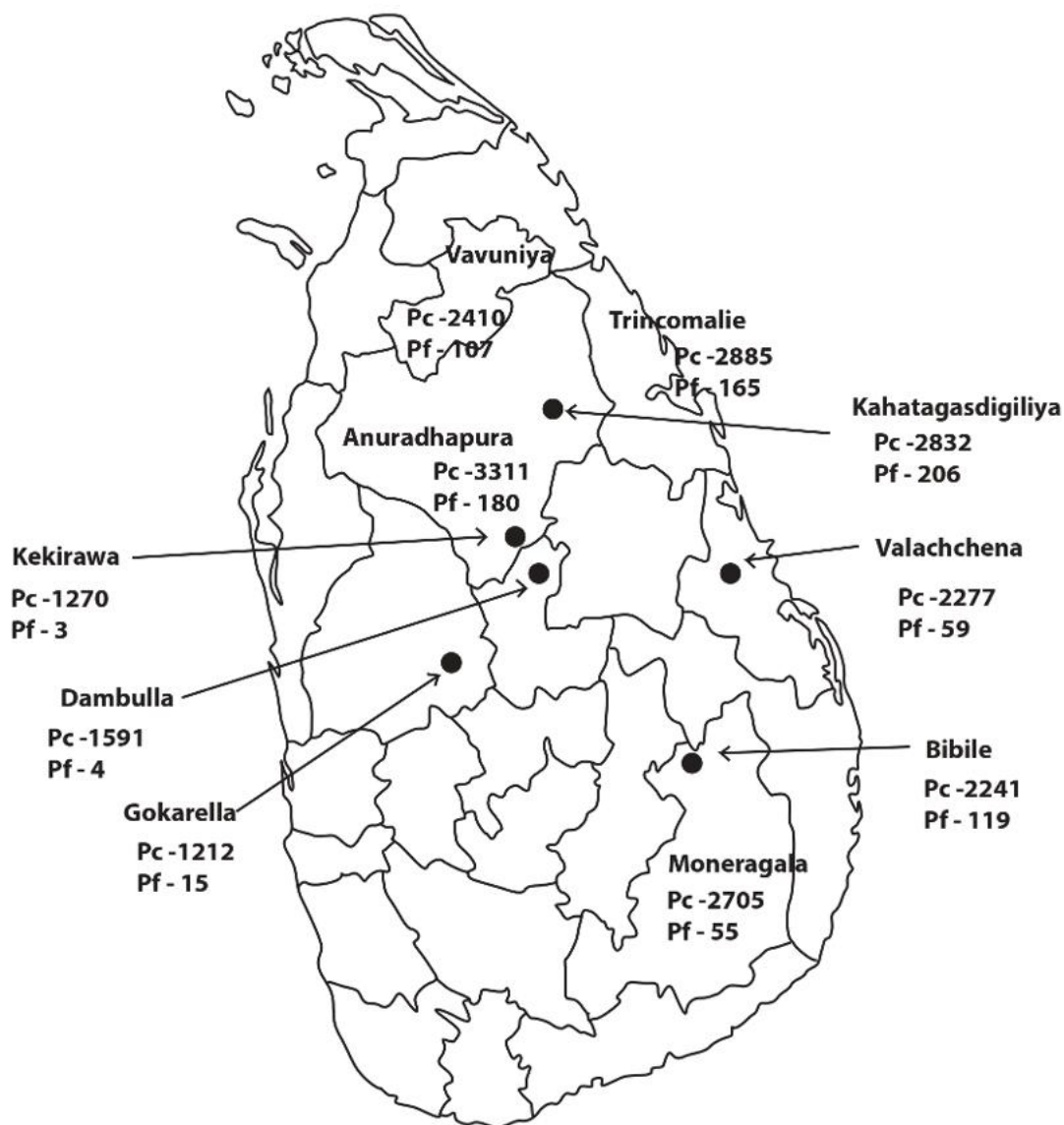


Figure 9 – Health areas with high malaria incidence in 1982

Following the increase that took place at the end of the preceding year, the year 1983 experienced a sharp rise in the total case incidence. A significant feature was that, in addition to the several health areas involved in the dry zone, districts in the intermediate zone too recorded a very high incidence – Figure 10.

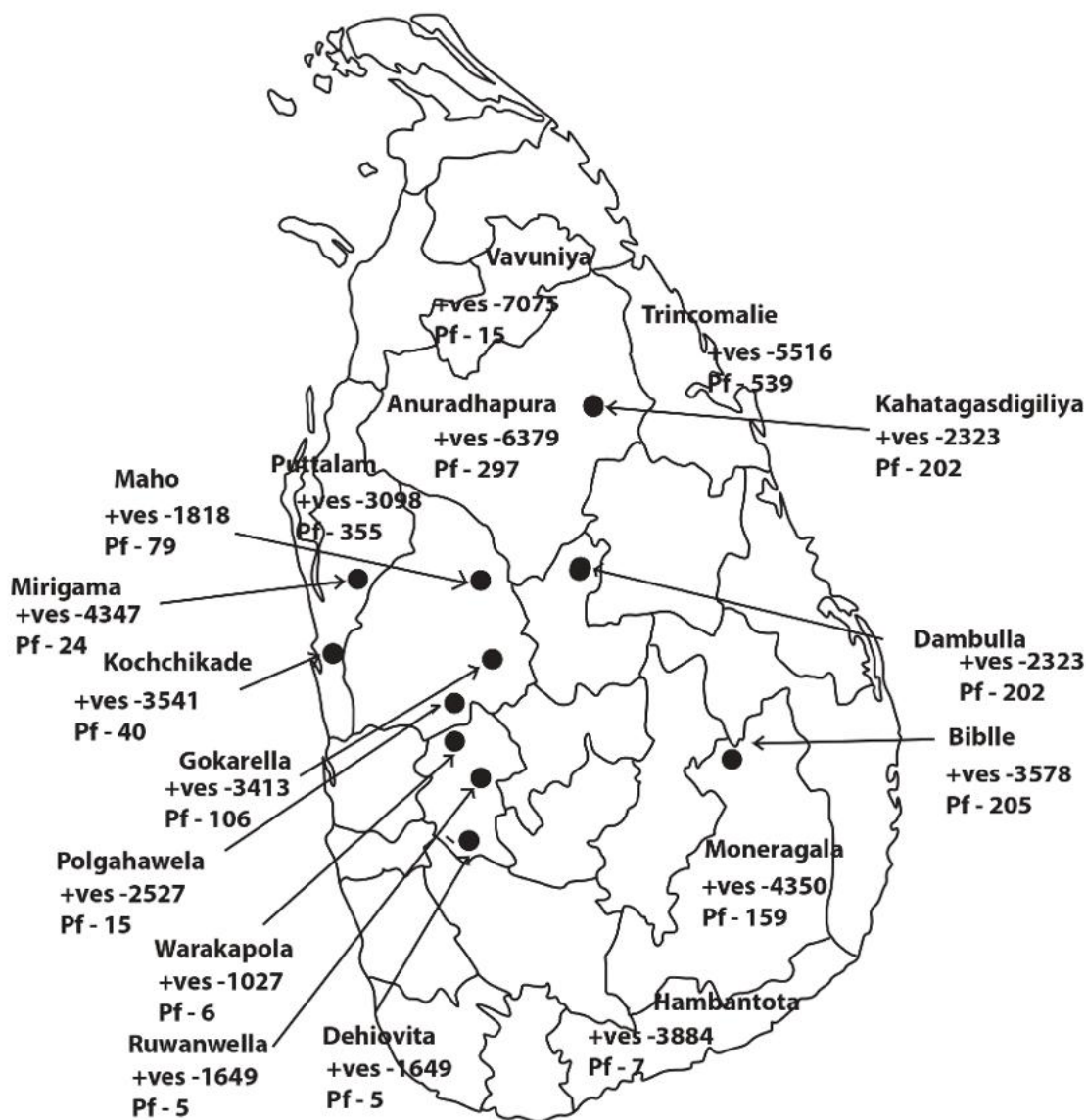


Figure 10 - Health areas with high malaria incidence in 1983

Possible causes for the sharp increase experienced during 1982 -1983 -

• Operational –

It has been commented in the Administration Report of 1983, that it was not the stratification process but the 'back-up' services that failed, meaning manpower and supplies. Out of the 16 posts of Regional Medical Officer in the Anti Malaria Campaign, 13 were vacant. The Health Services in Sri Lanka was experiencing an acute shortage of Medical Officers, specially in the preventive side. Although the entomological investigations carried out during the year, revealed survivors against the discriminating dose used (5% malathion, for 30 minutes), yet the level of resistance was not considered operationally significant from point of view of vector control activities. The limited number of drug resistance tests carried out (in-vivo and in-vitro) in Puttalam and Nochchiyagama, had revealed a high sensitivity status against chloroquine, in the local falciparum strains.

• Climatic –

The monthly totals of rainfall over the entire country, as measured by the 22 stations collecting routine data throughout the country, revealed that the rainfall was below normal during the period January to October 1983, except during the month of September.

• “Accelerated Mahaweli Development Scheme in ” and Malaria

How malaria became a major obstacle during the early colonization schemes such as Minneriya and Galoya schemes, is well known. With the launching of the massive “Accelerated Mahaweli Development Scheme” in April 1979, the largest single development scheme undertaken by the Government of Sri Lanka, malaria was certainly a problem to be anticipated. In this multipurpose project the main components are water storage and its diversion for the generation of hydroelectric power and irrigation, and development of physical and socio-economic facilities in the new settlements. The project harnesses the longest river in Sri Lanka, Mahaweli River, damming the river at several sites, and diverting the water either for agricultural purposes or the generation of hydroelectric power. Large scale human settlements were planned in the dry zone. The initial new settlements were in Anuradhapura district (System H), in the 70's the very first Township to be established being Galnewa (Kekirawa health area). Thereafter new settlements were established in Polonnaruwa districts (System B), Badulla distinct (part of System C), Ampara district (major part of System C), and in several other districts – Figure 11.

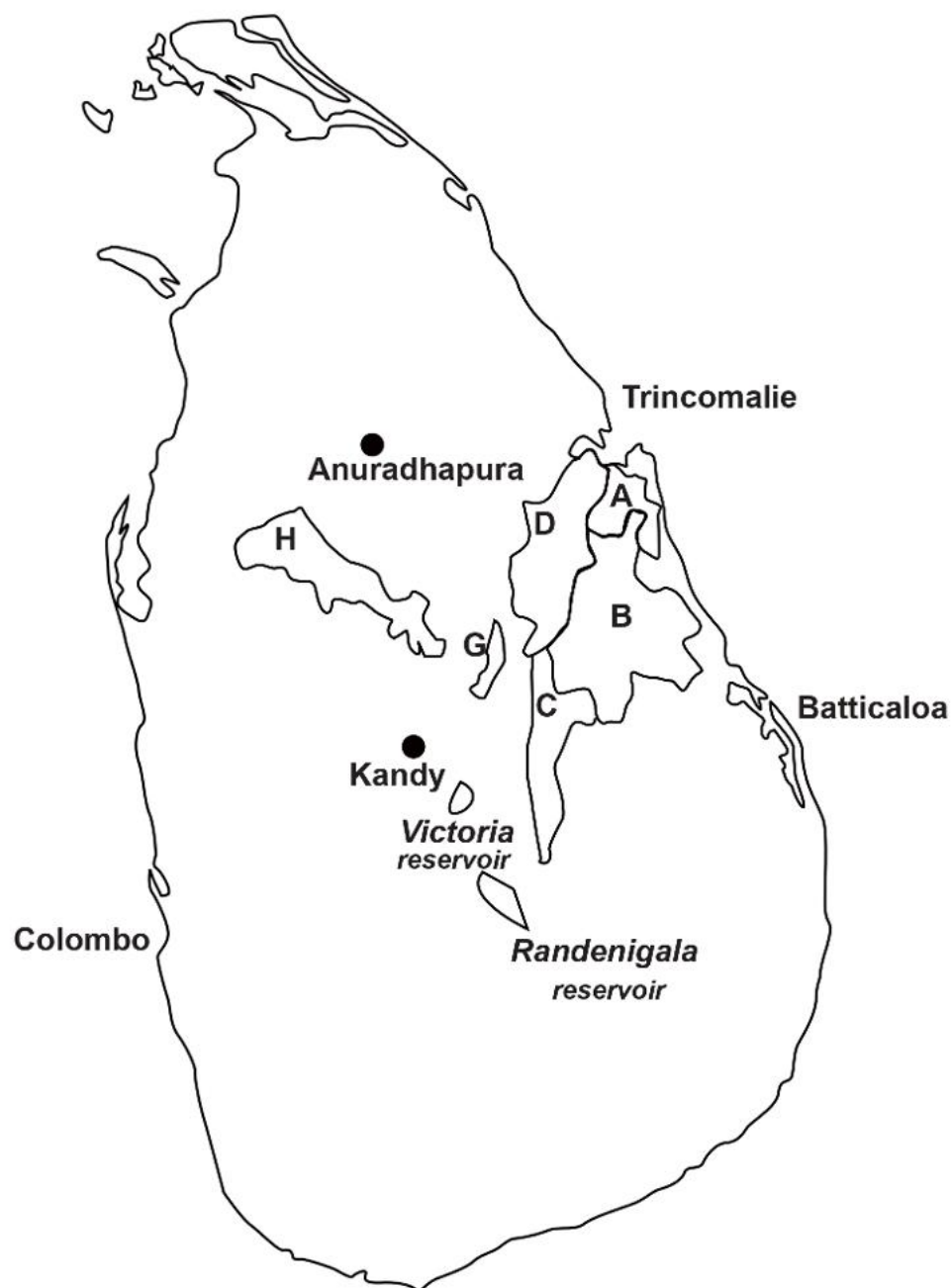


Figure 11 – Areas under “Accelerated Mahaweli Development Scheme’
Phase 1 & 2 (Systems A,B,C,D,G,H)

Several reasons contributed towards the problem of malaria in the new settlements. These new settlements were established after clearing jungle, and it was to be expected that *An. culicifacies*, a mosquito whose presence in the jungles had been established, and who would have been feeding on wild animals, now turning to humans to obtain their blood meals. According to the mode of settlement the houses were constructed by the settlers only after coming to reside in the area. Until the houses were completed they were accommodated in temporary buildings. Provision of effective residual insecticide spray cover was difficult in these temporary structures, as these buildings meant for community living often had only half-walls. Excessive man-vector contact was therefore invariable during the early stages of settlement. Another major factor was that the majority of the new settlers hailed from traditionally non-malarious areas in the country, lacking any acquired immunity against malaria, thus easily falling victims to the disease.

With the provision of water for irrigation purposes there were ecological changes. Water was provided to the farmers along a system of surface channels, usually earth-lined. Pocketed water along the sides of the smaller channels, and the vegetation often seen on the sides of channels, encouraged vector breeding.

The Anti Malaria Campaign, fully aware of the malaria potential in development project areas in the dry zone, implemented several strategies to minimize the problem. An attempt was made to obtain advance information on the settlement plans, from the Mahaweli authorities, to enable the Regional Malaria Offices to contact the prospective Mahaweli settlers moving from traditionally non-malarious areas.

The objective was to initiate weekly prophylactic treatment, prior to their migration. However this information was difficult to obtain. The Regional Malaria Offices and the Sub-Regional Offices in the districts of Anuradhapura, Polonnaruwa, Badulla and Ampara organized programmes to administer weekly prophylactic treatment to new settlers hailing from traditionally non-malarious areas, at settlement sites, during the first 3 to 6 months after arrival.

Mahaweli authorities were establishing a community development service in the new settlement areas. Duties of the Community Development Officers included health matters, and they soon realized that malaria was a priority problem. The Regional and Sub-Regional offices of the Anti Malaria Campaign carried out the control programmes with the active involvement of these Community Development Officers. Voluntary Malaria Treatment Centres were set up in Mahaweli townships and villages. The Community Development Officers were responsible for the selection of suitable personnel to act as volunteers, while the necessary training and the antimalarial drugs were provided by the Regional Malaria offices.

These volunteers treated persons with uncomplicated malaria diagnosed on clinical grounds, but were instructed not to treat infants, pregnant women, or those who were already under treatment for any other illness. Such persons were advised by the volunteers to seek treatment from a medical institution. At a time when medical institutions were just coming up in the Mahaweli development areas, and the transport facilities available for the settlers to reach medical institutions in main towns were scarce, the farmer families found these Voluntary Treatment Centres very useful. Regular inspections were carried out by staff from the Regional Malaria Offices, to ensure that correct dosages of the anti malarial drugs were given, and that the centres had the necessary drugs. Health education programmes were conducted by the Health Education Unit of the Anti Malaria Campaign, with the cooperation of the Resident Project Managers and their staff, often including open air cinema shows in the night, as video presentations were not possible at the time.

- Creation of new foci of malaria transmission

Creation of new foci of malaria transmission in the traditionally non-malarious areas was another problem consequential to the damming of the Mahaweli river and the new settlement process. Wijesundera reported that malaria transmission was observed in Kandy and its vicinity following the construction of the Polgolla dam across Mahaweli river, as a result of pooling in the river downstream. She also reported that travel between the new Mahaweli villages in the dry zone, and the original areas of residence of the Mahaweli settlers, was an important factor in the initiation of malaria outbreaks in latter, which were traditionally non-malarious. Kusumawathie also reported on malaria outbreaks in three traditionally non-malarious areas within the districts of Kandy and Nuwara Eliya, which were associated with population movements between the affected villages and Mahaweli areas.

First Appearance of Chloroquine-resistance in Sri Lanka - 1984

Since chloroquine-resistance in falciparum malaria emerged as a major problem in late 1950's and early 1960's, in South-East-Asia, Oceania, and South America, several countries in the region reported chloroquine-resistant falciparum strains. Sri Lanka was on the alert for possible appearance of chloroquine-resistant *P. falciparum* strains, and therefore routine drug-sensitivity studies were conducted by a team headed by the Medical Officer-in-charge of the Parasitology (later by the Parasitologist at the AMC), as a routine operational activity of the Anti Malaria Campaign. Both in-vivo and in-vitro investigations were conducted. Studies were conducted in localities where adequate numbers of falciparum malaria were found for the purpose. Regional Malaria Officer, Matale, who was carrying out a special programme of work in the village of Wewala in Dambulla health area (Matale district),

to control a malaria outbreak noticed that several *P. falciparum* patients treated by the special field team who were stationed in the locality, returned with fever within a few days, and that their repeat blood smears showed that the asexual parasitaemia had not cleared up in spite of the normal antimalarial regimen administered to them. The Parasitologist and her team investigated this falciparum focus, and reported that the 16 in-vitro tests carried out revealed 14 patients had chloroquine-resistance (R-1 type in three, and R-1 & R-2 type in eleven) , and that the 20 in-vivo tests carried out on patients from the same locality revealed R-2 type resistance in one case, and sensitivity or R-1 type resistance in the balance 19 cases. Thus chloroquine-resistant malaria was established in Sri Lanka, for the first time, in August 1984.

Remedial measures carried out in the first chloroquine-resistant falciparum focus

Four thousand five hundred *P. falciparum* cases had been reported during the year 1983, and this species was no longer confined to the areas which were labeled the traditional falciparum areas in the past. Therefore the Anti Malaria Campaign took a very serious view of the situation, and immediately launched a plan to combat the falciparum focus. Fortunately a limited stock of the combination drug (Sulfalene+pyrimethamine) which had arrived as a sample was available with the AMC, and therefore no time was lost treating the chloroquine-resistant patients with an alternative drug.

Two zones were demarcated for combat the focus:

Zone A (focus proper) - 5 contiguous villages, including Wewala, in which the outbreak first appeared (total population approx. 3350);

Zone B (outer surveillance zone) – a concentric area (approx 2 km wide) around the perimeter of Zone A.

The strategy to combat the focus comprised the following measures:

- Effective transmission control in both zones - The villages in both zone A and zone B were already under 3-monthly residual spraying with malathion, however to enhance the insecticide protection, all the sprayable structures in these villages were re-sprayed with malathion, under strict supervision. With the objective of achieving rapid reduction of the adult vector density in the two zones, space spraying (fogging) was carried out using an insecticide mixture of 5% Technical Malathion in kerosene oil, covering the villages, first at 3-day intervals, and

- subsequently at 10-day intervals. Application of the fog was done by using one truck-mounted type (TIFA 100 E), and a few knapsack-type machines. Intensification of detection of *P. falciparum* patients in both zones - A field laboratory was set up at Wewala, with 6 Microscopists functioning, to enable results of the examination of blood smears collected by the mass blood surveys, to be obtained without delay.
- Treatment of falciparum malaria cases in zone A, with an alternative drug regimen - The alternative drug given to *P. falciparum* patients detected in zone A, was the combination drug (sulfalene+pyrimethamine) at a dosage of 1000mg of sulfalene and 50mg of pyrimethamine (2 tablets) for an adult, and a proportionately lower dose to children to whom the drug was not given. This drug was withheld from infants and pregnant women. In such instances, an extended regimen of chloroquine was administered (over a 5 day period), there being a suggestion at the time that a 5-day regimen of chloroquine would be effective in cases of mild resistance. A single dose of primaquine was also administered along with the alternative drug, or with the extended chloroquine regimen, for its gametocytocidal properties. Primaquine was withheld from infants and pregnant women and from lactating women during the first 6 weeks of puerperium.

P. falciparum patients detected in zone B, were treated with the extended chloroquine regimen plus primaquine, latter drug being withheld from infants and pregnant women and from lactating women during the first 6 weeks of puerperium. The impact of the remedial measures -

The impact was reflected in the results of the mass blood surveys which were carried out at 10-day intervals – Figure 12.

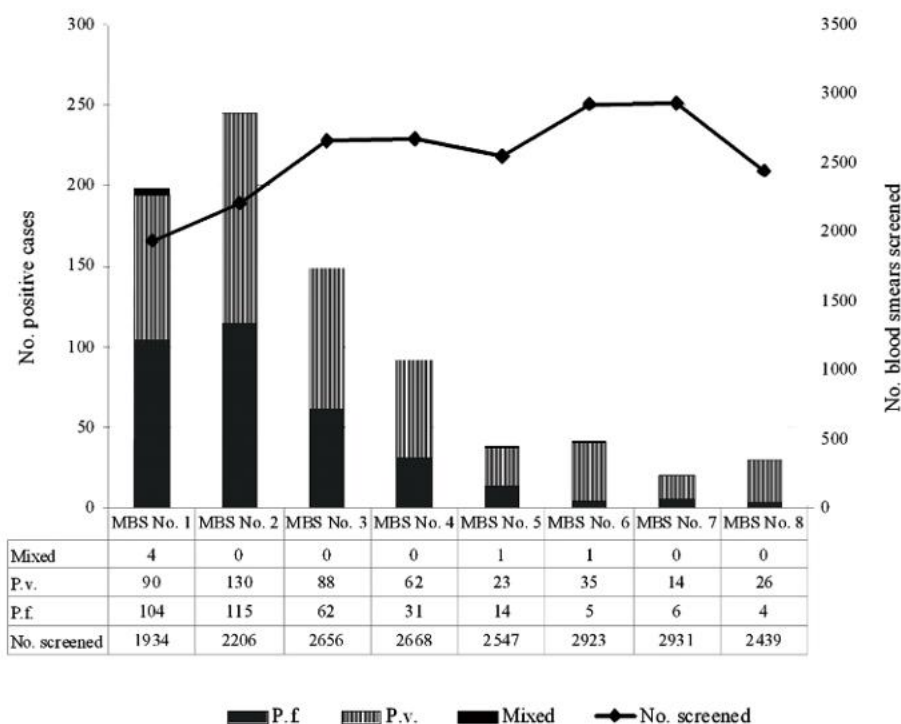


Figure 12 - Results of Mass Blood Surveys conducted in zones A & B

The in-vivo tests conducted revealed that those treated with the alternative drug, had complete clearance of asexual parasitaemia, by the 7th day of administration of the drug, and that they remained free of asexual parasitaemia, until the end of the test period (28 days). Even in the case of falciparum malaria patients treated with the extended chloroquine regimen, they remained free of asexual parasites during the 28 day period, except one patient in whom parasitaemia reappeared on the 21st day of treatment, after the initial parasite clearance following treatment.

Investigations carried out in the area, few weeks after the appearance of the falciparum focus, revealed that 100% mortality was exhibited by *An. culicifacies* (after 30 minutes exposure to 5% malathion), but *An. subpictus* showed only 9% mortality (after 60 minutes exposure to 5% malathion). However in both tests the samples were small. Remedial measures carried out in zones A and B were under the immediate supervision of Regional Malaria Officer, Matale and under the guidance of the AMC Head Quarters technical staff. Regular visits to the area were carried out by the Director and his technical staff. Changes in the treatment schedules following the emergence of drug-resistant falciparum malaria.

Important changes took place in the malaria drug treatment policies. A second-line treatment regimen had to be introduced to treat chloroquine-resistant falciparum malaria patients, and the clinicians had to be alerted to the problem. Clinicians were also advised how chloroquine-resistant falciparum malaria patients may be suspected, and subsequently confirmed by in-vivo test. Third-line treatment regimen was recommended for any chloroquine-resistant falciparum malaria patient who may be found also resistant to the 2nd line drug (S+P combination), or who cannot be given (S+P) drugs due to some reason such as pregnancy or sensitivity to sulfa drugs.

The following 2nd line regimen, and also a 3rd line regimen were introduced:

2 nd Line Regimen		
Adults	1000mg Sulfadoxine or Sulfalene + 45mg Primaquine	Pregnant women and those with a known history of allergy to sulfa drugs were not administered (S+P) drugs, but treated with quinine for a period of 7 to 10 days. Primaquine was not given pregnant women, and to lactating women during the first 6 weeks after child birth.
Children	proportionately lower doses	
Infants	Quinine only (for 7 to 10 days)	

3 rd Line Regimen	
Adults	Quinine 600mg three times a day for 7-10 days (if given orally) + 45mg Primaquine single dose (if not contraindicated)
Children	a proportionately lower dose (both drugs)
Infants	Only Quinine (proportionately lower dose)

Scheme for the Import and Distribution of alternative drugs for the treatment of chloroquine-resistant falciparum malaria in Sri Lanka

By now 6 countries in South East Asia had reported emergence of drug-resistant falciparum malaria strains, they were Thailand, Bangladesh, Nepal, Indonesia, India and Myanmar. It was also known that in some of these countries the free availability of alternative drugs had resulted in the early emergence of multi-drug resistant falciparum strains. Therefore the Anti Malaria Campaign exercised great caution, and had the wisdom to take strict precautionary measures to delay the emergence of multi-drug resistant falciparum strains in the country.

At the suggestion of the Anti Malaria Campaign the import of (S + P) drugs, were placed solely in the hands of the Department of Health Services, and its distribution in the hands of the Anti Malaria Campaign. Clinicians were advised to prevent the unwarranted use of alternative drugs in the treatment of falciparum malaria. These efforts had far reaching effects, and the efficacy of (S + P) drugs in the treatment of chloroquine-resistant falciparum malaria patients in Sri Lanka, was very much retained, except in a very few instances, even at the time when the Anti Malaria Campaign decided to change the first line drug regimen in the treatment of falciparum malaria. In April 2008, in keeping with the WHO recommendations to avoid monotherapy in the treatment of falciparum malaria, the Anti Malaria Campaign switched over to Artemisinin Combination drugs as the first-line of treatment for falciparum malaria.

The malaria epidemic in 1986/1987

In 1986, there was a sharp rise in the countrywide malaria incidence, associated with an alarming increase in the percentage of falciparum malaria. The falciparum percentage which was only 2.5% of the total cases, in 1984, had now reached 20.4%. Again, it was the traditionally hyperendemic areas in the dry zone which were affected. Polonnaruwa district had the highest number of *P. falciparum* cases. Wijesundere who served as the Physician at the government Base Hospital in Polonnaruwa, during the epidemic, reported that the parasite rates among those living in the new colonization areas of system 'B' of the Mahaweli Scheme, were found to be much higher than in those living in the areas such as Polonnaruwa town and Hingurakgoda which were colonized several decades ago. Wijesundere attributed the high infection rates among these new settlers who came from traditionally non-malarious areas (and hence non-immune), as the most significant cause of the epidemic situation in Polonnaruwa. Additionally, she identified as contributory factors, the rainfall pattern that prevailed in Polonnaruwa district in the year 1986, and the defective residual insecticide spraying programme in the district. Excessive rainfall from the North East monsoon, received during the period January to March, and the moderate rainfall received in May, from the South West monsoon, were considered responsible for the two peaks of malaria encountered in the district in March 1986 and July 1986, respectively.

A spontaneous fire occurred in the main insecticide store in November 1985, which resulted in the destruction of the entire stock stored there. Only the stocks those were in the regional stores were available for indoor residual spraying. This caused difficulties in the implementation of an effective residual spraying programme until stocks were replenished early next year. The temporary shortage of malathion for the residual spraying programme, and the problem of mounting refusals towards house spraying, by the householders, had much adverse effects.

Widespread pilferage of malathion from the field depots, was another problem faced by the Anti Malaria Campaign. Due to the banning of malathion import for all purposes other than malaria control, a popular pesticide previously used by farmers was now not available to them. Without being able to appreciate the logic of this restriction, many farmers sought to obtain malathion unlawfully from spraying units, leading to widespread pilferage of malathion. Although legislation was brought in to declare transport, possession, selling, or the use of malathion, illegal for unauthorized person, it was difficult to tackle this problem. Pilferage from the field-depots of the spraying units resulted in poor

quality spraying, because in such instances the suspension sprayed was too dilute.

During the year 1987 a recorded number of 1.97 million blood smears were collected by the surveillance mechanisms of the Anti Malaria Campaign, out of which 687,599 were diagnosed positive, with the following breakdown:

<i>P. vivax</i>	502,134 cases (73.0%)
<i>P. falciparum</i>	184,326 cases (26.8%)
Mixed infections	1,139 cases (0.2%)

The districts of Anuradhapura, Polonnaruwa, Matale, Kurunegala, Puttalam and Hambantota had the highest intensity (API > 100/1000 population) during the year 1987. The rapid increase of falciparum infections during the epidemic was also accompanied by the extension of this infection to many health areas outside the traditional falciparum areas, including most health areas in the intermediate zone and even some health areas in the wet zone.

Causes of the 1987 epidemic

Both operational and technical factors were responsible for the massive increase in malaria transmission during 1987. Whereas more blood smears were collected and examined during the year, following the decentralization of the malaria microscopic services, repeated infections were encountered in many areas due to the high transmission potential.

- Chloroquine-resistant falciparum strains were gradually extending to all parts of the country in which malaria transmission was taking place.
- The residual spraying programme was far from satisfactory, for several reasons. On the part of the public, the increasing refusal rate towards spraying of houses was creating a big problem to the campaign. The attitude of the householders discouraged the spray team personnel. Supervision of the malaria control field activities by the supervising officers, especially the insecticide spraying programme, was found to be far below the required standards. The insecticide resistance tests carried out during the year revealed a very high level of susceptibility of *An. culicifacies*, to the discriminating dose of malathion.

- The problem was compounded by the poor security situation which prevailed in several districts, causing frequent interruptions in the field programmes.

USAID Malaria Control Project

Subsequent to the termination of the 1977-1982 five- year “Intensive Malaria Control programme”, in which the government of United States was the major donor agency, the United States Agency for International development (USAID) again agreed to assist the malaria control activities in Sri Lanka, for a 5 year period. A novel procedure introduced by the USAID on this occasion was to channel the assistance through a private consultant agency based in Washington, USA, the Industrial Science & Technology Institute (ISTI). Two long-term consultants, a Malariologist and an Entomologist were based in Colombo, who operated from the Anti Malaria Campaign head quarters premises, maintaining their own office. This project assisted the programme, in several different areas, including training, research, logistics (including insecticides) and the promotion of ‘Integrated Vector Control’, for which Hambantota district was selected for conducting the pilot project.

The training programme sponsored by the USAID project was very comprehensive, covering several categories of technical staff of the Anti Malaria Campaign. A number of residential training programmes (training of trainers) were conducted by international consultants with wide experience in modern training methodologies. Several members of the technical staff, both from the Campaign directorate and the Regional level received training in Comprehensive Vector Control at the University of South Carolina, USA. Some received training in Epidemiology, from leading universities in USA.

With the important objective of fostering inter-sectotal collaboration towards malaria control, several inter-departmental/agency workshops were held in Colombo and at district level.

Promotion of the use if insecticide-impregnated mosquito nets -1986

The efficacy of insecticide treated mosquito nets, both as a personal protection measure, and as a tool to reduce malaria transmission through its large scale use, had been proven and its use in the prevention and control of malaria, was recommended by the WHO. The Anti Malaria Campaign recommended the use of insecticide treated nets in malaria-endemic areas during 1986, and actively facilitated the process by carrying out insecticide-treatment of nets

belonging to the public, free-of-charge, using Permethrin Emulsion Concentrate to prepare the mixture required for the immersion of the net.

Years 1988 & 1989

In the year 1988, a very substantial reduction in both vivax and falciparum infections, was witnessed, former reduced by 42.4% and the latter reduced by 49.2%. There was no significant improvement in the residual insecticide spraying programme, but it was thought that the posting of microscopists in the medical institutions, carried out in 1986, was showing the beneficial effects now. The rainfall was also adequate throughout the year, and therefore was conducive to a declining trend in transmission. However things took a different turn towards the last quarter of the year when the security situation in the country deteriorated badly, compelling the last spray cycle for the year, be almost completely abandoned, resulting in an upsurge of malaria transmission during the months of the last quarter.

Decentralization of Malaria Control Activities - 1989 - 2000

March 1989 was a very important milestone in the health service of Sri Lanka, in general, and in particular, for the Anti Malaria Campaign which until then functioned as a strictly vertical campaign. In accordance with the 13th Amendment to the Constitution of the Democratic Republic of Sri Lanka, the subject of Health was also devolved, along with many others. Consequently, the responsibility of national policy formulation, liaison with international donor agencies, provision of technical guidelines to the provinces, basic training of certain categories of malaria control personnel, inter-provincial coordination with regard to malaria control, countrywide monitoring and evaluation, and the promotion and coordination of research activities were placed with the Anti Malaria Campaign Directorate. Provision of insecticides and spraying equipment, too remained the responsibility of the Directorate. The implementation of the malaria control programme within the respective province, provision of logistical support, and conducting in-service training programmes for some categories of malaria control personnel, were made functions of the provincial health authorities. Thus the Regional Medical/Malaria Officers were placed under the purview of the provincial authorities, administratively, but remained under the technical guidance of the Director of the Anti Malaria Campaign.

Radical changes took place in the head quarters of the campaign. The non-technical staff was reduced to less than a third of the original number, due to transfers to the provincial and district level offices of the provincial health authorities. The central garage and the workshop which were attached to the campaign directorate were placed under the administration of the Transport Division of the Health Ministry.

Much beneficial effects ensued. The ownership of the district malaria programme implementation having passed over to the provincial health authorities, as to be expected the provincial health authorities played a more responsible role in malaria control. The Medical Officers of Health began playing a more pivotal role in malaria control. Under the new scheme majority of the malaria field workers in the district came under the purview of the respective Medical officers of Health, and the latter took a much more active role in malaria control.

One disadvantage was that at the early stages budgetary problems were experienced owing to the fact that the monetary allocation from the Central Government to the provinces were made en masse. There were occasions when the allocation of funds for district malaria control activities were inadequate. However with the commencement of foreign funded projects situation improved considerably.

Malaria outbreak during 1991 – 1993

During the years 1991 to 1993 the countrywide malaria incidence rose again. A remarkable feature seen in 1991 and 1992 was the steady rise in the annual incidence in the districts of Jaffna, Kilinochchi, Batticaloa and Trincomalee, compared to the incidence in 1990. The malaria trend in the two northern districts of Mannar and Mullativu, could not be assessed due to inability to obtain malaria data for the years 1991 and 1992. Data was available for the northern district of Vavuniya only for the years 1990 and 1992, and in the latter year the incidence had risen by almost four fold. Very clearly the effect of the conflict situation on the Northern and Eastern districts was visible. Apart from the highly disrupted malaria control field programmes, sending antimalarial drugs and insecticides to these districts also became very difficult.

Apart from the malaria situation in the Northern and Eastern districts, the rising incidence in the districts of Anuradhapura and Moneragala, between 1990 and 1993, was alarming. On the other hand the annual incidence in Matale district had declined between 1991 and 1993. In the districts of Ampara, Kurunegala, Puttalam, Matale, and Hambantota, substantial reductions were seen between the period 1991 and 1993 – Figure 13.

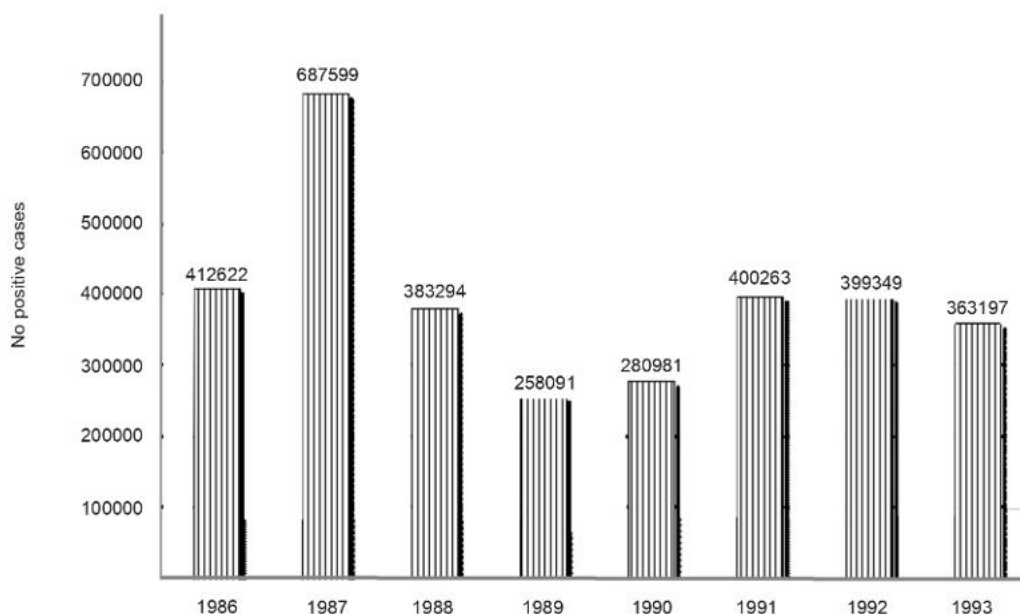


Figure 13 – Malaria incidence – 1986 – 1993

Changing susceptibility of *An. culicifacies* to malathion

Since the introduction of malathion in the residual spraying programme, on a limited scale in 1975, and on an extensive scale in 1977, the Anti Malaria Campaign regularly monitored the vector susceptibility status. During the period 1985 to 1989, few survivors of *An. culicifacies* were detected against the discriminating dose (5% malathion for 30 minutes), in some health areas in the Northern and North Western parts of the country, but taking the overall situation, susceptibility of *An. culicifacies* against malathion remained at a high level in most of the sprayed areas throughout the country. The situation changed from 1989 onwards, with increasing numbers of survivors being detected from most of the areas, specially in intermediate zone. In 1992 and 1993, low susceptibility levels were recorded from Western, North Central, Central, North Western and Sabaragamuwa provinces, however, the malathion susceptibility of *An. culicifacies*, in Uva and Southern provinces was at a high level during this period. *An. culicifacies* populations in the Eastern foot Hills area remained fully susceptible to malathion until 1994. While an isolated population in Lunugamwehera area (Southern province) revealed a high level of malathion resistance in 1994, the inevitable happened by 1995. Populations sampled in almost all areas showed resistance to malathion.

Effect of the spreading malathion resistance on malaria transmission became obvious. The big increase in transmission encountered in 1991 (400,263 positive cases as compared to 279,172 in the preceding year) was persistent. The North Western province, in which low susceptibility levels were recorded from 1992 onwards, experienced a tremendous rise in the incidence.

Change of residual insecticide in Kurunegala and Puttalam districts

It was realized that the situation in the North Western Province could not be controlled unless the residual insecticide in use was changed. By this time two candidate insecticides were ready in case replacement was necessary. One was an Organophosphate (Fenitrothion), and the other was a Synthetic Pyrethroid, a new generation insecticide (Lambda cyhalothrin). Village trials had been conducted and target dosages had been determined. An important change took place in the residual insecticide programme when malathion was replaced by Lambda-cyhalothrin, in Kurunegala district, in August 1993, and malathion was replaced by Fenitrothion, in Puttalam district, in 1994. By now the development of malaria vector resistance against an increasing number of insecticides in use was a global problem. The WHO had recommended strategies of rotational use of chemically unrelated insecticides, and also the

use of chemically unrelated insecticides in adjacent areas, as useful means of delaying insecticide resistance in vectors. Therefore the Anti Malaria Campaign decided to introduce two different insecticides belonging to two different groups, in the two adjacent districts. Because of the higher mammalian toxicity of fenitrothion, compared to malathion, more stringent safety measures were introduced, specially with regard to the spraying team personnel. The frequency of monitoring of the cholinesterase level of the spraying team personnel, which was carried out once in 3 months when handling malathion, was changed to fortnightly intervals, and more personal protection measures were recommended.

The impact of the change of insecticide in the two districts was spectacular – Figure 14.

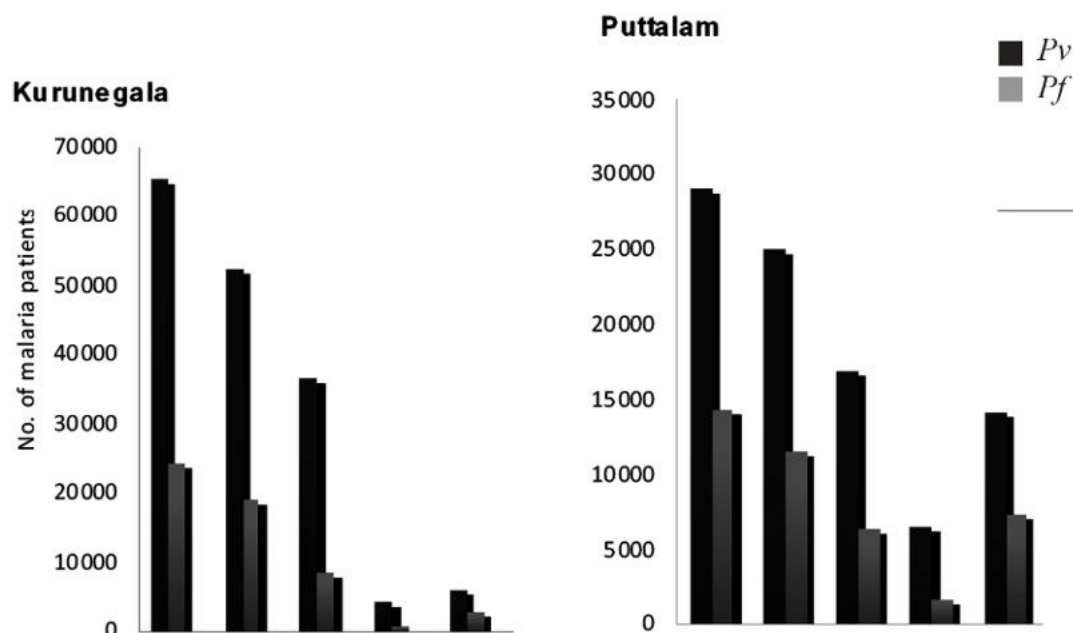


Figure 14 – Malaria incidence in Kurunegala & Puttalam districts – 1992 – 1996

The conflict situation – its effects of on malaria

Severe public health problems affect populations facing complex emergencies has been evident throughout the world. Sri Lanka was no exception. The conflict situation which had its roots in the late seventies gradually escalated and its effects on malaria transmission within the country was quite obvious as the years went by. Between 1993 and 1994, the total case load of the two adjacent districts Jaffna and Kilinochchi, more than doubled itself, Kilinochchi recording the highest annual parasite incidence in the country, in 1994 (121/1000 population). These two districts had the highest incidence experienced during the preceding 50 years, a direct result of the conflict situation. Malaria data was not received regularly from the districts of Mannar and Mulativu, but there were indications that the malaria transmission in these two districts was high, judging from reports from government medical institutions and from international agencies such as ICRC and MSF providing medical services in the conflict affected districts. The epidemiology of malaria in the country was changing. Instead of climatic factors, the security situation in the districts became a determining factor of the intensity of transmission. In the year 2000, the districts in the Northern and Eastern provinces, all of which were conflict-affected in varying degrees, contributed 50.3% of the total number of positive cases detected by the surveillance mechanisms of the Anti Malaria Campaign

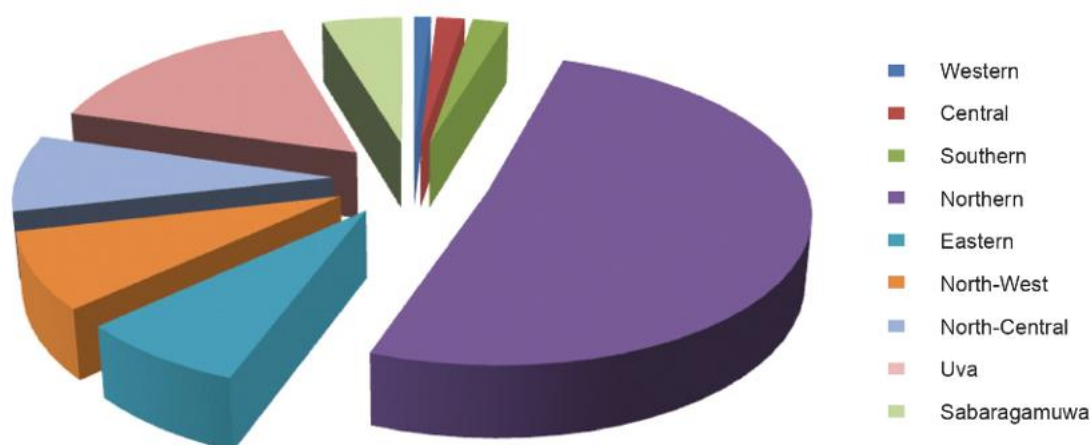


Figure 15- Contribution of malaria incidence from each province in Sri Lanka during 1998 – 2002 (Cumulative No. of cases)

The cause for the escalation of malaria transmission in the conflict-affected districts was multi-factorial:

- The main control measure, residual spraying programme came to a virtual standstill.
- The detection and treatment of malaria patients, was adversely affected in several ways. Functioning of the medical institutions was severely hampered due to shortage of both personnel and drugs including anti malarial drugs. The patients experienced many difficulties in accessing medical institutions.
- Often the land route for sending items to the Northern districts was closed, and the Anti Malaria Campaign had to depend on dispatching insecticides and drugs by the sea route. Availability of space in vessels, for insecticides was limited, as food items got priority for obvious reasons. Insecticide boxes were prone to get spoilt by sea spray, during unloading, and therefore special methods of safe transport had to be adopted.
- Internally displaced persons, both intra-district and inter-district, were common. These displaced persons were even more vulnerable to malaria, because their temporary dwellings were not readily amenable to residual insecticide spraying and access to diagnostic facilities and treatment was more difficult.
- Malaria among the uniformed services personnel was too a considerable problem. Due to the nature of their duties they had more exposure to infected bites, as the practice of personal protection methods was often not practicable.
- Even the districts neighbouring the Northern and Eastern provinces were affected. In the border villages such as Padaviya (Anuradhapura district), Welikanda (Polonnaruwa district), and Siyambalanduwa (Moneragala district), more malaria cases were detected. In the border villages too, at times the security situation was not conducive enough for the spraying units to carry on their work, and hence interruptions in the spraying programme were seen. Occupants of houses in some border villages were in the habit of spending the nights in hiding in nearby jungles, to avert the danger of terrorist attacks in the night, thereby becoming prone to much increased man-vector contact.

A special problem was the spread of chloroquine-resistant falciparum strains among the uniformed services. In a study conducted in Mannar, Hapuarachchi et al found very high percentage of chloroquine-resistant falciparum malaria infections among security forces personnel, carrying out both in-vivo and in-vitro tests. This also created a risk of dissemination of chloroquine-resistant falciparum malaria infections throughout the country, as the security personnel detailed for duty in the conflict-affected areas were on a rotational basis, reporting back for duties in non-conflict areas periodically. Travel to their places of permanent residence during periods of leave, was also common. Detection of resistance to anti malarial drugs and follow-up procedures in the treatment of drug-resistant malaria cases were severely hampered due to the acute shortage of facilities for microscopic examination of blood. Anti malaria campaign took every effort to obtain the cooperation of the many non-governmental organizations which were providing medical care in the affected areas to send across whatever possible supplies of anti malarial drugs and insecticides. A request was made from all NGOs to adhere to the drug regimens recommended by the Anti Malaria Campaign, in the treatment of malaria patients.

Technical assistance from the WHO

From its very inception the WHO considered malaria control a priority global issue. The assistance the government of Sri Lanka received towards its struggle to control malaria has been immense. Malariologists, Entomologists, Parasitologists, and Sanitarians, both long-term and short-term, have served in Sri Lanka as WHO Consultants, at various times, side by side with the national counterparts, providing valuable services. At present Malaria Control is a regular item in the WHO Country Office agenda for providing technical assistance.

In the past decades the anti malaria campaign received WHO assistance in the following areas:

- Control of Malaria Epidemics
- Capacity Building
- Evaluation of the Country Programme
- Monitoring Drugs Sensitivity (anti malarial drugs)
- Monitoring Vector susceptibility to insecticides
- Exchange of technical Information

IDA/World Bank Malaria Control Project - 1997 – 2001

The World Bank agreed to provide financial assistance to several health programmes in the country. Malaria control was one of the priority areas identified, and the proposal submitted by the Anti Malaria Campaign was approved for funding. This Malaria project, which originally covered the districts of Matale, Polonnaruwa, Anuradhapura, Puttalam, Moneragala and Hambantota, was subsequently extended to cover Jaffna and Vavuniya of the Northern province and Ampara and Trincomalee of the Eastern province as well. The objective was to supplement the malaria control activities of the malaria control programme.

The main activities carried out with the financial support of the project were:

- Conducting Mobile Malaria Clinics and quality control of microscopy
- Strengthening Entomological investigations
- Strengthening supervision of field programmes
- In-service refresher training programmes
- Review of Malaria control activities
- Provision of insecticide-treated-mosquito nets
- Operational research activities

- Malaria Mobile Clinics (MMC)

Thirty 4-wheel driven double-cab vehicles were received under the project, and Anti Malaria Campaign embarked on active case detection in high-transmission areas supported by the project, by conducting Mobile Malaria Clinics. The malaria treatment seeking pattern in most of the rural areas had a common feature, in that there was a considerable delay between the onset of fever and reporting for diagnosis and treatment. Very often the patient took only antipyretics in the intervening period. This was commoner in people who lived in remote villages away from the nearest medical institution. Therefore it was envisaged that if diagnostic facilities and treatment are taken to such localities, it would prompt people suffering from fever to report for blood smear examination and malaria treatment, at a much earlier stage in their illness. Then, the Anti Malaria Campaign would succeed in detecting malaria patients, and treat them, at a much earlier stage than before. Several benefits would accrue. The patient obtains relief very early; complications are minimized as the parasitaemia ceases early; and transmission is reduced due to the early destruction of gametocytes. The clinic team comprised a Public Health Field

Officer, a Public Health Laboratory Technician, a labourer, and the driver of the clinic vehicle. The blood smears taken would be stained and examined, and treatment handed over, within a period of approximately 45 minutes. The itinerary of the clinic would be notified in advance. During periods when prevalence of malaria was low, and only a few persons reported to the mobile clinic, the Public Health Field Officer would carry out house visiting in search of persons having fever or who have had fever during the preceding 4-week period. Two hundred Binocular microscopes were procured to strengthen case detection activities.

During the monthly review meetings held with the Regional Medical/Malaria Officers of the project districts, it became very clear that conducting mobile malaria clinics was a very productive step. Analysis of the results of blood smear examination revealed that a high percentage of positive cases were from the blood smears taken by the mobile malaria clinics. This meant that a large number of malaria parasite carriers got treated within a shorter period of the illness, than before. During periods when the basic reproduction rate is high this would have a much beneficial effects in reducing transmission.

- Strengthening Entomological investigations

With the support of the project funding each district managed to conduct entomological surveillance activities for additional 12-days per month. This supported the districts to stratify the areas for different mechanisms of vector control as well as to predict the outbreaks. Establishment of Six Regional Entomological Labs were also supported under this project.

- Review of Malaria control activities

Monthly meetings with the participation of the Regional Malaria Officers and the central level technical staff were held to review the malaria control activities conducted specially under this project. These meetings provided the opportunity to discuss the constraints & challenges encountered in project implementation as well as to obtain technical advice from the central level technical staff to regional staff, obtain necessary supplies and equipments for the districts from the central stores, and exchange of surveillance data.

- Strengthening supervision of field programmes, in-service refresher training programmes and provision of insecticide-treated-mosquito nets

Supervision of field programmes were supported by providing additional funding to meet expenses on fuel and per-diem as well as by providing 120 motorcycles for the Public Health Inspectors. Series of in-service training programmes were conducted for all the categories of staff engaged in malaria control activities. Nearly 100,000 mosquito nets and insecticides necessary for impregnation of them were also supplied to the project districts.

Other than the main activities described above this project provided anti-malarial drugs, insecticides for vector control, Rapid diagnostic test kits to detect malaria parasite in the localities where the services of Microscopists were not available, and equipments & funds necessary for programme management. The 5-year IDA/World Bank Malaria Control project contributed significantly to bring down the incidence of malaria in the 10 districts supported by the project – Figure 16.

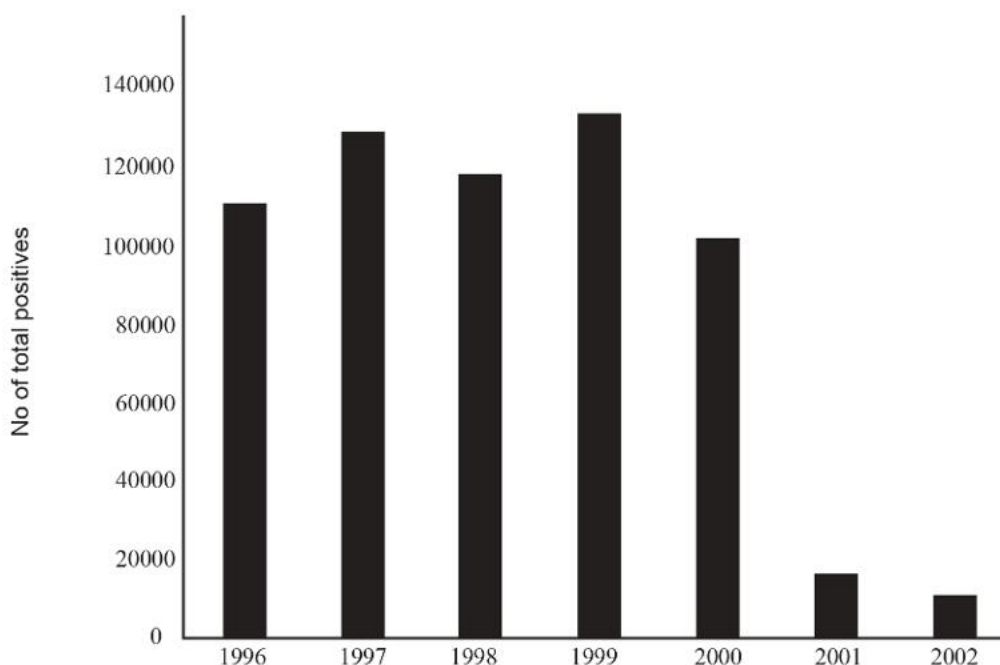


Figure 16 - District-wise Malaria incidence in IDA/WB supported districts – 1996 – 2002 (Cumulative No. of cases)

The Roll Back Malaria Initiative of the WHO - 1999 - 2003

This special programme was endorsed by the World Health Assembly held in 1998, and was launched in South East Asia region, in 1999. The goal was to reduce the global malaria burden by 50%, by the year 2010. The initiative was to rely on a six-pronged strategy:

1. Early detection
2. Rapid treatment
3. Multiple means on prevention
4. Well coordinated action
5. A dynamic global movement
6. Focused research

A total of 24 pilot districts were chosen by 7 Member States. Districts of Jaffna, Kilinochchi, Mulativu, Anuradhapura and Moneragala were the districts selected from Sri Lanka. The basis for selection of these 5 districts from Sri Lanka, was that over 70% of the positive cases detected in the country during the preceding 3 years, were recorded from these 5 districts.

At WHO regional level three Technical Support networks were established, to provide the necessary technical support to the member countries on:

- Transmission Risk Reduction
- Surveillance, Information Management and Epidemic response, and
- Drug resistance & Policy.

At the country level the milestone activities were situation Analysis and Needs Assessment in the 5 districts; establishment of the National Action Group, Technical Support Group and the Malaria Research Committee; and the establishment of Provincial/District Core Groups.

The following Impact Objectives were formulated:

- The malaria incidence for the year 2000 to be reduced by 50 %, by the year 2005;
- Malaria mortality encountered in the year 2000 to be reduced by 75 %, by the year 2005;
- To reduce the incidence of malaria in the working population, internally displaced population, pregnant women, and children under 10 years of age.

Malaria Control in the New Millennium - 2001 - 2010

Along with the dawn of the 21st century a new window of opportunities were provided for the National Malaria Control programme; reported malaria incidence been remarkably low due to the strategic control measures conducted during the last decade. The temporary cessation of the conflict situation during 2002 – 2004 and finally resolving it in 2009, with the launching of the intensive malaria control activities with financial assistance from the donor communities in addition to Government efforts further brought significant reduction in the malaria incidence during 2001 – 2010.

During this period two National Strategic Plans (NSP) for malaria control were developed for the periods 2005 – 2009 and 2008 – 2012.

Strategic Plan 2005 - 2009

The goal of this Strategic Plan was 'Total interruption of indigenous transmission of malaria in Sri Lanka by the year 2015'.

The main objectives were:

- To reduce the national Annual Parasite Incidence (API) by the year 2009, to a level 50% below that in 2003;
- To eliminate mortality attributed to malaria, by 2009
- To reduce the nationwide morbidity due to *Plasmodium falciparum* to a level 50% below that in 2003 by the year 2009
- To eliminate malaria among pregnant women by the year 2009
- To reduce malaria in children below 5 years to a level 50% below that in 2003 by the year 2009.

The countrywide malaria incidence declined further during the year 2006. In keeping with the declining malaria incidence, the objectives of the NSP 2005-2009 were revised as follows:

- To reduce the API among at risk populations in the country by the year 2009, to a level less than 25 % of that in 2005 (0.4 per 1000 in 2005)
- To reduce the proportion of *P. falciparum* infections to less than 3 % of all reported malaria infections, by the year 2009 (5.7% in 2005)
- To sustain zero mortality from malaria
- To prevent outbreaks/epidemics of malaria in the country
- To eliminate the occurrence of malaria infections in pregnant women, by the year 2009

- To reduce the proportion of malaria infections in children below 5 years to less than 5 % of all reported infections by the year 2009 (10 % in 2005)

The strategies proposed in the plan are:

- Early detection and prompt treatment of cases
- Detection and treatment of asymptomatic parasite carriers
- Selective application of vector control measures based on the principles of integrated vector management
- Forecasting and prevention of outbreaks
- Early detection and containment of outbreaks
- Partnership building and community participation
- Human resource development and capacity building
- Regular assessment of the programme and effecting changes if and when required
- Promotion of operational research

Strategic Plan 2008 – 2012

Further remarkable reduction in the malaria incidence motivated the Anti Malaria Campaign and the partners to consider the possibilities in eliminating malaria at least from some parts of the country. The new strategic plan was developed, for the period 2008-2012, intending to launch pre-elimination phase of malaria control programme. At the time of the formulation of this Strategic Plan, unfortunately the conflict-situation in some of the districts in Northern Province had not ceased, and therefore the Anti Malaria Campaign envisaged demarcating the country into 3 zones, stable (Non-conflict) districts, Transition districts (recently cleared areas) and conflict-affected districts – Figure 17. According to the plan phased elimination of *P. falciparum* malaria from the entire country excluding the conflict affected districts, and the elimination of *P. vivax* malaria from nearly 75% of the land area of the non-conflict affected districts would be facilitated.

The main objectives are:

- To eliminate indigenous *P. falciparum* malaria by the year 2012 in non-conflict & transitional areas of the country;
- To eliminate indigenous *P. vivax* malaria by the year 2012 in 75% of non-conflict & transitional areas of the country;
- To reduce API in conflict affected areas to 75% of the API reported in 2007, by the year 2012;
- To maintain zero mortality from malaria in Sri Lanka

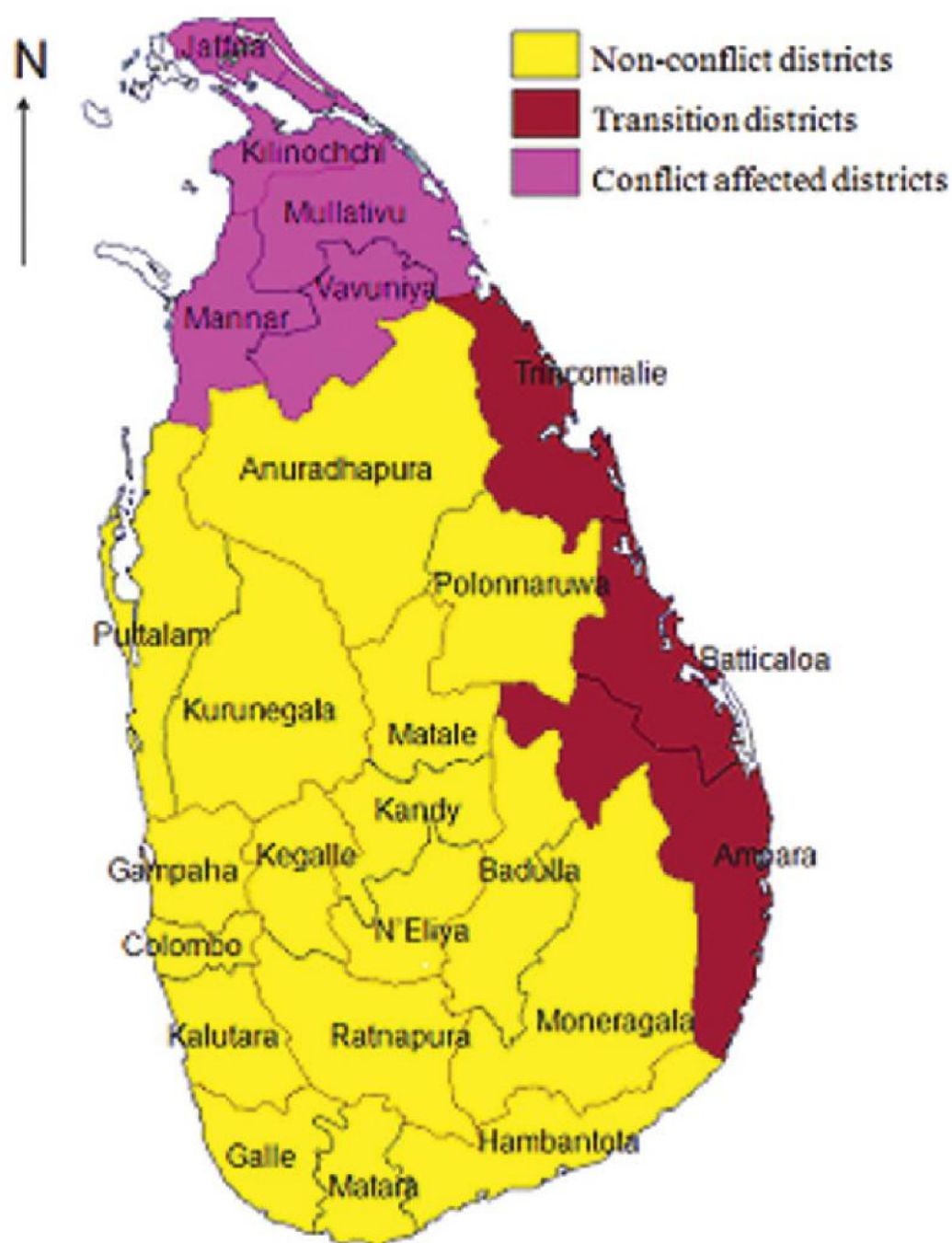


Figure 17 – Three zones identified in the elimination attempt in the Strategic Plan 2008-2012

Strategies for malaria elimination in non-conflict & transitional areas are:

- Ensure 100% case detection and confirmation by microscopy or RDT, notification and radical cure.
- Strengthening surveillance system
- Implement radical treatment policy for all *P. vivax* infections
- Continue ACT & gametocyte treatment policy for *P. falciparum* malaria.
- Implementing a quality control & quality assurance for diagnostic & treatment services including anti malarial drugs.
- Ensure total IRS coverage in foci and the distribution of LLINs/ITNs and other vector control measures as complimentary measures in specific situations
- Implementation of an outbreak preparedness and rapid response strategy for early containment of outbreaks
- Prevention of malaria in travelers
- Re-orienting public & private health sector staff towards the new goals of malaria elimination.
- Advocacy for political commitment, partnerships and enhancing community participation
- Human resource development & capacity building

Strategies for malaria control in conflict affected areas are:

- Strengthening case detection and confirmation by microscopy or RDT, notification and radical cure.
- Strengthening the malaria surveillance system
- Implement radical treatment policy for all *P. vivax* infections
- Continue ACT & gametocyte treatment policy for *P. falciparum* malaria.
- Increase IRS coverage and the distribution of LLINs/ITNs and other vector control measures as complimentary measures in conflict affected areas where feasible
- Advocacy for political commitment, partnerships and enhancing community participation
- Human resource development & capacity building
- Operational research

According to the Strategic plan it is budgeted that US\$ 42,448,000 is required to operationalize this plan during 2008 – 2012 excluding salaries of the staff and transport cost.

The Global Fund to fight AIDS, TB and Malaria (GFATM) was established in 2002 to assist the countries to combat AIDS, TB and Malaria. Anti Malaria Campaign saw a window of opportunity to intensify the malaria control activities in the country.

GFATM - Round 1 Project – 2003 - 2008

The 1st malaria project to “Intensive malaria control among the hitherto marginalized populations in conflict-affected districts in Sri Lanka, who are presently afflicted with a very high malaria burden” was supported by GFATM during 2003 - 2007. Under this project malaria control activities of districts of Jaffna, Killinochchi, Mannar, Mulativu, Vavuniya, Trincomalee, Batticaloa, Ampara, Polonnaruwa and Anuradhapura were supported. The eight districts in the Northern and Eastern provinces had contributed to 68% of the countrywide malaria morbidity during the year 2001. Furthermore, of the total deaths attributed to malaria during 2001, the Northern and Eastern districts contributed 92.5 %. Implementing a project in close collaboration with NGOs was a new experience for the Anti Malaria Campaign.

The main objectives of the project were:

- Reduction of the parasite reservoir in the population living in the districts of Northern and Eastern provinces and adjacent districts
- To establish partnerships with the community and community service organizations
- Prevention of malaria in pregnancy
- Prevention of malaria transmission
- Containment of drug-resistant *P.falciparum* malaria strains
- Programme management and capacity building

Impact of the project -

This project commenced in April 2003, and considerably helped the Anti Malaria Campaign to control malaria in the project districts. The main thrust area was in early detection and treatment through active case detection by means of Mobile Malaria Clinics - Figure 18.



Figure 18 - Conducting a Malaria Mobile Clinic

Acute shortage of Public Health Laboratory Technicians prevailing in the project districts, especially in the Northern and Eastern districts, was a severe constraint for confirmatory diagnosis of malaria, and species differentiation. Spread of chloroquine-resistant falciparum malaria was causing a significant problem in controlling falciparum malaria in the project districts. The provision of Rapid Diagnostic Test kits by the project was invaluable in making arrangements to have a confirmatory diagnosis along with species differentiation, by means of mobile clinics, and also in medical institutions. The transport facilities were also funded by the project fulfilled a long felt need for suitable vehicles to cover difficult terrain in the project districts, especially in conducting Mobile Malaria Clinics. To enhance detection of malaria cases in the districts where the Microscopists were not adequate, 'Malaria Assistants' were trained to conduct malaria microscopy. In addition screening of malaria parasites among the school children (Figure 19) and pregnant women attending Ante Natal Clinics were also strengthened. Entomological surveillance and supervision were the other activities supported by this project in the selected districts.



Figure 19 - Screening of school children for Malaria

Long Lasting Insecticidal Nets (LLINs) were introduced as a malaria control tool in the country, for the first time in Sri Lanka, under this project (Figure 20). A large number of LLINs were procured and distributed to the project districts. Total budget received under the project period was US\$ 6,711,110.



Figure 20 – Use of Long Lasting Insecticidal Net (LLIN) by a family

Reduction of malaria incidence to very low levels was a remarkable achievement in the project districts at the end of the 5-year period – Figure 21.

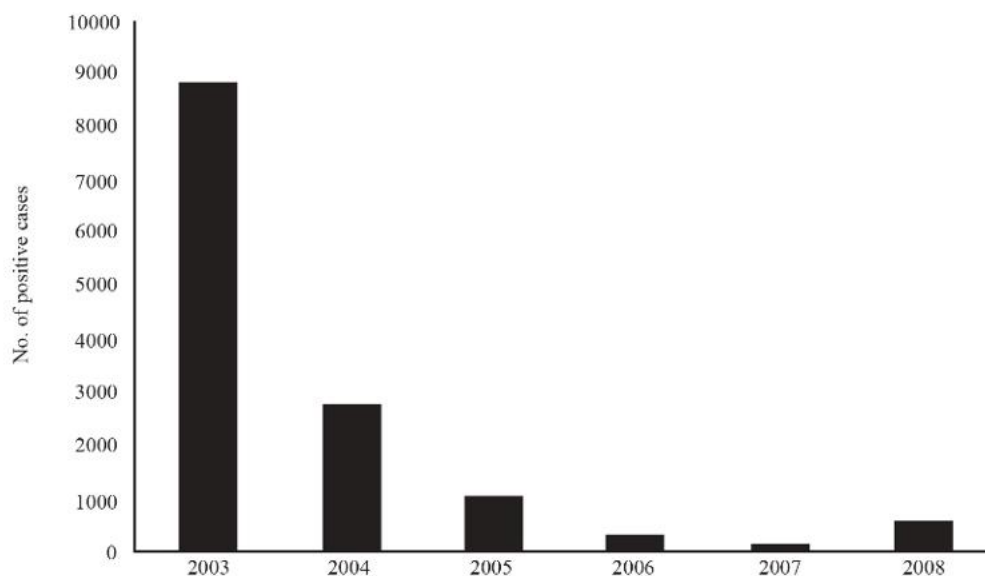


Figure 21 - Malaria incidence trends in GFATM project districts during R-1 (2003-2007) Grant (total number of cases from project districts)

GFATM - Round 4 Project – 2005 - 2009

With the malaria incidence in the districts covered by the previous GFATM project declining in a very satisfactory manner, the Anti Malaria Campaign now diverted its attention to certain districts in which mobile populations had been the cause of past outbreaks and epidemics. Prevention of malaria outbreaks and epidemics was an important objective of the control programme. Therefore, another proposal covering these districts was submitted for “Expansion of the activities of the National Malaria Control Programme of Sri Lanka to improve coverage of mobile population groups with enhanced risk of malaria and who have been contributory to malaria epidemics in the past”.

This proposal too was accepted for funding main objectives been:

- To reduce malaria transmission among mobile and vulnerable populations
- Well focused vector control methods in an eco-friendly manner
- Strengthening of the epidemic forecasting system by augmentation of entomological surveillance
- Programme management and capacity building

Districts covered under this project were Puttalam, Kurunegala, Matale, Ratnapura, Hambantota and Moneragala. The project activities commenced in September 2005. Emphasis was on the detection and treatment of malaria parasite carriers among mobile populations such as gem-miners and cultivators engaged in slash-and-burn type plantations (chena cultivators). Malaria incidence in the project districts was low, and therefore detailed investigation of cases and foci was possible. It was emphasized that the Regional Medical/ Malaria Officers now carry out their control measures in a strictly evidence-based manner, even more than before, because more time was now available for detailed investigation of malaria cases detected.

Total budget received under the project period was US\$ 2,984,654. Reduction of malaria incidence to low levels was an achievement in the project districts at the end of the 5-year period – Figure 22.

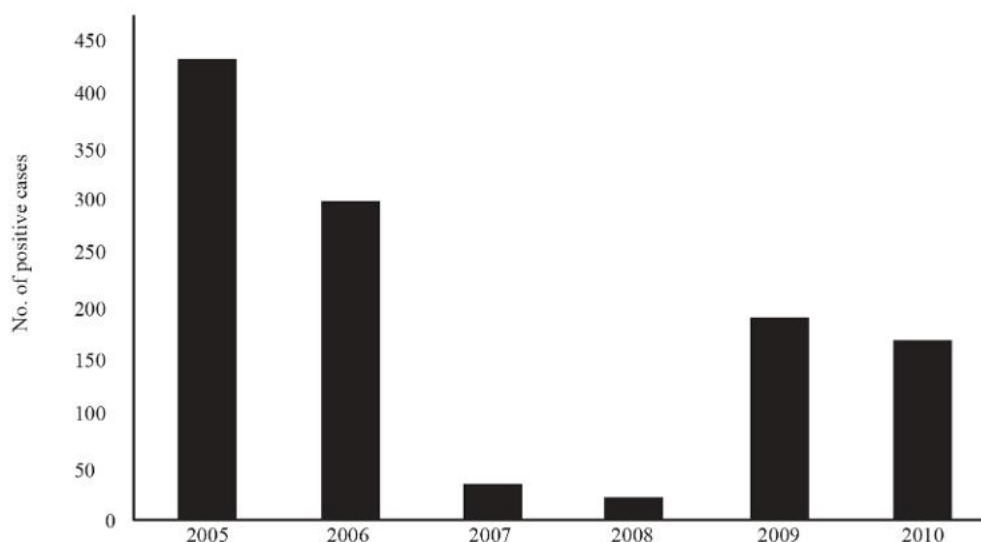


Figure 22 - Malaria incidence trends in GFATM project districts during R-4 (2005-2009) Grant ((total number of cases from project districts)

GFATM - Round 8 Project – 2009 – 2014

Obtaining remarkable achievements in GFATM two rounds of grants National Malaria Control Programme embarked on elimination of indigenous malaria in several selected districts. Sri Lanka submitted another proposal for GF Round 8 grant for “Elimination of *P. falciparum* malaria from non conflict districts and transitional districts and the elimination of *P. vivax* malaria from 75% of the above areas and the strengthening of malaria control in the conflict affected districts of Sri Lanka”. All the districts in the 3 zones described in the current National Strategic Plan are covered under this project. Total funding request in the GF Round -8- Malaria proposal was US\$ 40,915,151. In the Phase I country will be receiving US\$ 21,630,381 for the period October 2009 – September 2011.

Aims of the proposal -	Expected outcomes -
-strengthen morbidity and vector surveillance in all three zones (non-conflict, transitional and conflict areas) - coordinate malaria control activities with evidence based surveillance data in a timely and appropriate manner to ensure containment of outbreaks of disease with a view to ultimate elimination -ensure provision of adequate stocks of antimalarials including ACTs in all areas including the conflict areas -increase awareness regarding malaria elimination in non-conflict and transitional areas and to improve compliance to antimalarials	- No indigenous cases of falciparum malaria in non conflict and transition areas. - No indigenous cases for vivax malaria in 75% of the areas of the non conflict and transition areas. - No mortality due to malaria in the country. - Mandatory investigation of all malaria cases reported including a review of investigation - 90% of <i>P. falciparum</i> cases completing 3 day treatment, 90% of <i>P. vivax</i> cases completing 14 day treatment.

- strengthen the health system in the transitional areas with development of appropriate infrastructure - strengthen coordination, advocacy and partnerships including private-public partnerships at national, regional and community levels in reaching the most affected people in conflict areas for intensification of malaria control activities - strengthen capacity including human resources in health care delivery and information system development to support intensification of malaria control in conflict areas and a phased elimination of malaria from other areas (non-conflict and transitional)	- 95% of houses sprayed in malaria foci. - Each family has at least one LLIN especially in conflict affected and bordering areas. - Enhanced community awareness on malaria elimination and increased participation in facilitation of interventions. - Contribute to the achievement of Millennium Development Goals 4 & 5 relating to reduction in child & maternal mortality. - Reduction of poverty as a result of decreased disease burden and increased agricultural productivity in conflict areas and a phased elimination of malaria from other areas (non-conflict and transitional)
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Factors which contributed to the decline in the incidence of malaria in Sri Lanka

In the authors' opinion several factors have contributed to the decline of the malaria incidence in the country, and its maintenance at a considerably low level – Figure 23.

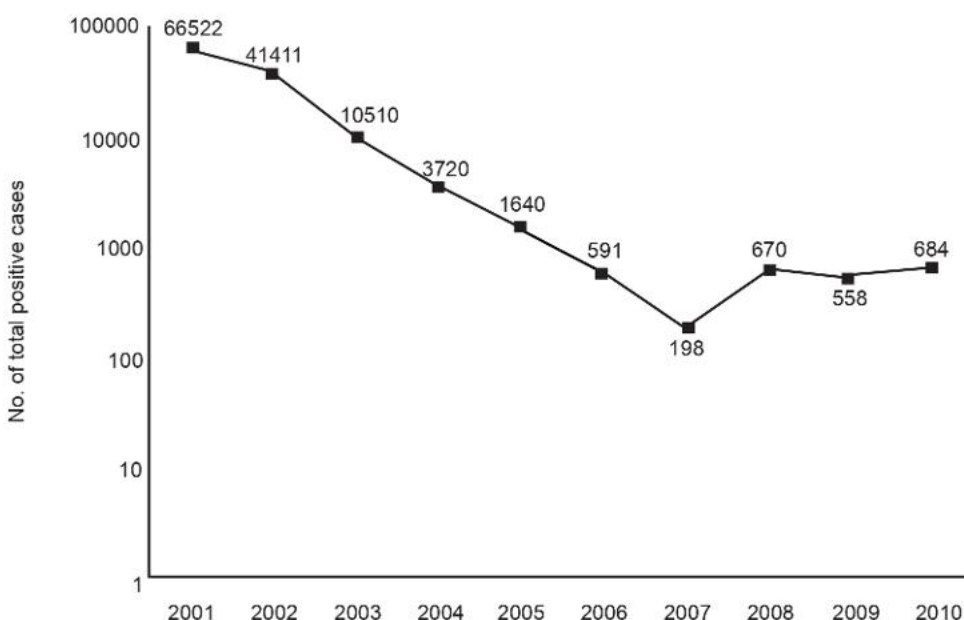


Figure 23 –Secular trends of Malaria in the last decade – 2001 – 2010

1. Strong political commitment

From the time it was realized that effective malaria control is a most important pre-requisite for the socio-economic development of the country, all successive governments have provided unstinted support for malaria control. Even during the years when adequate resource allocation has been a difficult task, there being unexpected items of state expenditure, malaria control activities in the country were not made to suffer due to lack of financial resources.

2. Strategic technical contribution

Malaria in Sri Lanka is a focal disease, and control measures applied in a too generalized manner often fail. Having realized this, there was an attempt to re-orientate the technical officers of the Anti Malaria Campaign, both at the central and district levels, to study vigorously the dynamics of malaria transmission in different ecological situations, and to adopt appropriate control measures to suit the various different situations. This exercise reaped its rewards, and taking evidence-based decisions eventually formed the basis of district strategies.

Several strategies to delay the emergence of vector resistance to the residual insecticides in use were implemented commencing in the early nineties, when synthetic pyrethroids were first introduced to the residual spraying programmes. The target dosage was determined after carefully carrying out hut trials using several alternative target dosages, to enable the most appropriate dose to be determined, avoiding unnecessary insecticide pressure. It was decided that at least two different groups of residual insecticides would be used simultaneously in different areas, and that the two groups would be rotated at periodical intervals. Since then synthetic pyrethroids and an organophosphate are in use. The residual spraying programme was based on a more rational manner. The Regional Medical/Malaria Officers had a key role in scheduling the indoor residual spraying programme, in time and space, in the respective districts under their purview, but in accordance with the National Malaria Control Policy. The necessity of evidence-based decision making was emphasized constantly, and a regular dialogue was maintained. The Entomology Division provided much valued support by monitoring the insecticide susceptibility status of the vectors, and also by assessing the quality of residual spraying by conducting Bioassay tests. The Ministry of Health ensured an uninterrupted supply of residual insecticides, by providing the necessary funds.

It was fortunate that *P. vivax*, the preponderant specie, remained quite sensitive to chloroquine. Although chloroquine-resistant *P. falciparum* infections were encountered, the stringent measures taken by the Anti Malaria Campaign succeeded in containing the spread of such strains. Responding to the effective transmission control measures, the incidence of falciparum malaria as a whole, declined to extremely low levels. Much criticism was leveled at the Anti Malaria Campaign, specially in the nineties, that the first-line treatment schedule for the treatment of falciparum malaria recommended by the campaign was obsolete and that alternative drug regimens should have been used. The wisdom of not taking hasty decisions has been proven by the fact that Sri Lanka is one of the very few countries in the South-Asia region, in which chloroquine is

still quite effective against falciparum malaria. However, in keeping with WHO recommendation against using monotherapy for the treatment of falciparum malaria, now the Anti Malaria Campaign has changed the first-line treatment schedule for *P. falciparum* malaria infections, to the combination drug (artemether + lumefantrine).

3. Enhanced parasitological surveillance through Mobile Malaria Clinics

The functioning of the Mobile Malaria Clinics, which commenced with the first World Bank Malaria Control Project in the two districts of Matale and Polonnaruwa has been a strategical step in the reduction of transmission. Malaria patients, who usually seek diagnosis and treatment, only after few days (ranging 2 to 7 days) of development of the symptoms, unless the symptoms are severe, are infectious to the vector mosquitoes when gametocytes are present in the peripheral blood. In vivax malaria infections gametocytes appear very early in the infection. When the Mobile Clinic visits a village, it is the authors' experience that persons with fever readily report to the clinic to have a blood smear examination. The malaria patients among them can commence antimalarial treatment very early. Furthermore, many asymptomatic parasitaemia cases have been detected and treated by these clinics. These persons otherwise would have gone unnoticed, being infectious to the vectors. By this mean parasite reservoir could be brought down to very low levels.

4. Timely introduction of new tools for malaria control

Introduction of the use of Rapid Diagnostic Test (Pv/Pf type) in malaria control work was a definite positive step in improving case detection with species differentiation. Use of the RDTs commenced at a time when treatment of suspected malaria cases on clinical grounds, was of common occurrence in the then conflict-affected districts because of the acute shortage of facilities for malaria microscopy.

The use of insecticide treated mosquito nets was introduced in 1986, but it was the introduction of Long Lasting Insecticidal Nets (LLINs) in large numbers, made possible by the GFATM projects that made a definite dent in transmission in areas they were distributed. Approximately 300,000 LLIN s were received through the first project (approved in 2002), and approximately 500,000 LLINs through the second project (approved in 2004). No doubt, the use of LLINs contributed in a very big way to the reduction in malaria transmission in the districts they were distributed.

5. Operational Factors

The decentralization of the implementation of the malaria control programme, which took place in March 1989, following the general decentralization of activities of government ministries, was a definite step towards better coordination between the Anti Malaria Campaign, run as a vertical campaign until then, and the general health services, under whose purview the Medical Officers of Health, field Public Health Inspectors, and the Public Health Midwives are. These field officers regularly visit the households in their respective health areas, and very often are the first persons to learn about unusual happenings in a locality, such as increased fever incidence. Technically guided by the district level Regional Medical/Malaria officers, and working in coordination with the field officers attached to the Anti Malaria Campaign working within the health area, their teamwork has resulted in effective implementation of malaria control activities.

The decentralization process resulted in another very significant advantage, in that the authority to make district-level decisions within the framework of the national policy, was granted to provincial health authorities. Decisions involving the implementation of urgently required malaria control measures, specially at times of malaria outbreaks, could now be quickly made at a peripheral level. This is extremely useful in our country situation in which unstable malaria results in frequent outbreaks.

With the implementation of the World Bank Malaria Control Projects, the monitoring system of the Anti Malaria Campaign was much strengthened, and was even more reinforced through the GFATM projects. Monthly reviews attended by the Campaign Directorate staff and the Regional Medical/Malaria officers, were held. This proved to be a very effective strategy in maintaining a close watch over the district malaria situation, with provision to make bilateral decisions on any corrective action that was required.

Capacity building of the technical officers of the Anti Malaria Campaign, both at central level and regional level, was given much emphasis. Training comprised local training and overseas training. A definite improvement was observed in the skills of the technical staff at all levels, in performing their respective functions.

6. Other factors –

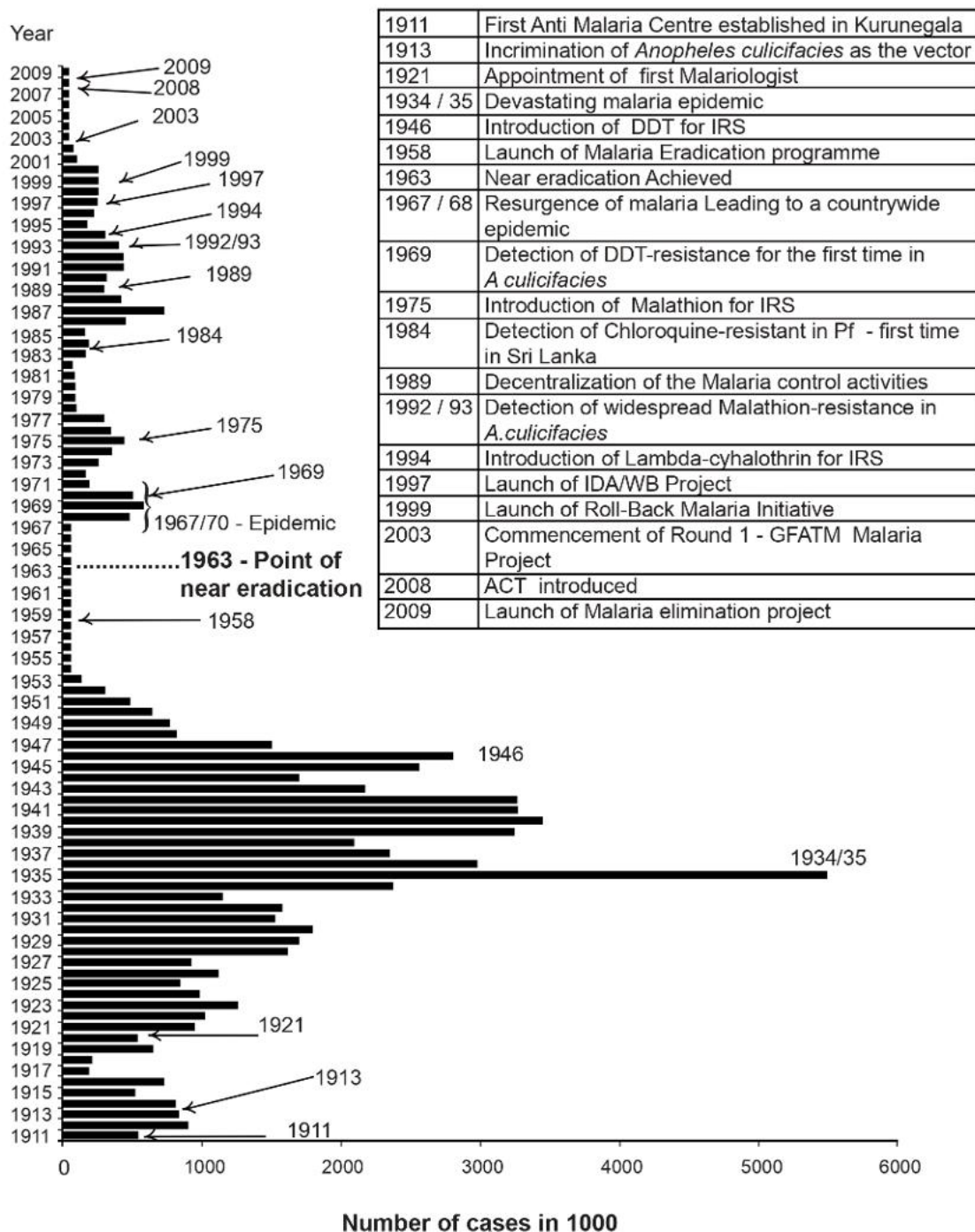
Climatic factors were much in favour during the last decade, with no significant drought affecting the intermediate zone.

7. Multisectoral support -

At various stages during the programme, the funds received from multilateral agencies such as the USAID, World Bank, and the GFATM were invaluable in meeting the ever increasing costs of malaria control.

The continuous technical support received from the World Health Organization has been most encouraging and contributed in no small way to the progress achieved in malaria control. In the early years Malariologists, Entomologists, Parasitologists, and Sanitarians from the WHO had been resident in Sri Lanka, guiding the local staff. At present assistance in many areas, mainly capacity building through in-service and international training is provided through the WHO Country Budget.

Above all, a well committed staff engaged in malaria control activities at all levels has been the greatest strength!



Malaria incidence in Sri Lanka with important mile stones.

REFERENCES

1. Abeyesundere, A.N.A, (1976) Report on 'Causes of Failure of the Malaria Eradication Programme, Sri Lanka in 1963-1964 and the corrective measures adopted in 1976'; Anti Malaria Campaign Records.
2. Abhayawardana, T.A., (1997), Insecticide Resistance Status of Mosquito Vectors in Sri Lanka. Paper presented at the WHO Inter- country Workshop on Insecticide Resistance of Mosquito Vectors, Salatiga, Indonesia.
3. Administration Report for the year 1958 - Director of Health Services, Sri Lanka. Administration Reports of Anti Malaria Campaign, Department of Health Services, Sri Lanka. 1966/67, 1969/70, 1974, 1976 1980, 1982, 1983, 1987.
4. Annual report of the Anti Malaria Campaign (2006).
5. Brohier, R.L (1941) The History of Irrigation and Agricultural Colonization in Ceylon – The Tamankaduwa District and the Elahera-Minneriya Canal. Reprinted in 1998 by the Academy of Sri Lankan Culture.
6. Bouma, M. J., Van der Kaay, H. J (1996) The El Niño Southern Oscillation and the historic malaria epidemics on the Indian subcontinent and Sri Lanka: an early warning system for future epidemics? Trop Med Int Health.1(1): 86-96.
7. Carter, H. F (1927) Report on Malaria and Anopheline Mosquitoes in Ceylon Ceylon, Sessional Paper V11, Govt. Press, Ceylon.
8. Clarke, J.L, Herath, P.R.J, Wickramasinghe, M.B (1974) Studies on DDT Resistance in *Anopheles culicifacies* in Sri Lanka. WHO/ MAL/74.826.
9. Gill, C.A (1935) Report on the malaria epidemic in Ceylon in 1934-35,

- Sessional Paper XXX111, Ceylon Government Press.
10. Hapuarachchi, H.A., Dayanath, M.Y., Abeysundara, S., Bandara, K.B., Abeyewickreme, W., de Silva, N.R. (2004), Chloroquine-resistant falciparum malaria among security forces personnel in the Northern Province of Sri Lanka. Ceylon Medical Journal.
11. Herath, H.M.S.S.D (2001) A Brief History of the Public Health Services in Sri Lanka. The Journal of the College of Community Physicians of Sri Lanka, Millennium Supplement.
12. Jayasekera, N., Chelliah, R.V (1981) An annotated checklist of mosquitoes of Sri Lanka, Man and the Biosphere National Committee of Sri Lanka. 8: 16, UNESCO.
13. Kusumawathie, P.H.D. (1995), Human Migration and Malaria Control in Malaria Outbreaks, M.Phil Thesis, University of Peradeniya.
14. Litsios, Socrates (1996) The Tomorrow of Malaria. Ecotrends.
15. Mahaweli Authority of Sri Lanka - www.mahaweli.gov.lk
16. Najera, J.A., Kouzentssov, R.L., Delacollette, C (1998) Malaria Epidemics - Detection and Control, Forecasting and Prevention, WHO, Geneva.
17. Ratnapala, R., Subramaniam, K., Yapabandara, M.G.M., and Fernando, W.P. (1984), Chloroquine Resistant Plasmodium falciparum in Sri Lanka. Ceylon Medical Journal
18. Rajendram, S., and Jayewickreme, S.H (1951) Malaria in Ceylon (Part 1) – The Control and Prevention of Epidemic Malaria by the Residual Spraying of Houses with D.D.T. Indian Journal of Malariology.
19. Report by the Departmental Committee on Malaria (1945), Malaria Control in Ceylon, Ceylon Sessional Paper, XVIII, Govt. Press of Ceylon.
20. Sivagnanasundram (1973) Reproduction Rates of Infection during the 1967- 1968 P. vivax Malaria Epidemic in Sri Lanka (Ceylon). Journal of Tropical Medicine & Hygiene.
21. Strategic Plan for Malaria Control in Sri Lanka - 2005 – 2009; Anti

22. Malaria Campaign, Ministry of Health, Sri Lanka.
Strategic Plan for Elimination of Malaria - 2008 – 2012; Anti Malaria Campaign, Ministry of Health, Sri Lanka.
23. Subramania, K, Ratnapala, R., Fernando, W.P. and Herath, P.R.J., (1985), *Plasmodium falciparum* resistance in Sri Lanka, Paper presented at the meeting on Drug Resistant Malaria, SEARO/WHO.
24. The Global Fund to fight AIDS, Tuberculosis and Malaria - www.theglobalfund.org.
25. Visvalingam, T (1961) A Review of the Problem and Control of Malaria in Ceylon. *Journal of the Ceylon Public Health Association*, Vol 11 (New Series).
26. Wijesundera, M. de S.. (1988) Malaria Outbreaks in new foci in Sri Lanka *Parasitology Today*.
27. Wickremasinghe F.A (1969), An Epidemiological analysis of the malaria epidemic in Ceylon – paper presented at the Seminar in Applied Epidemiology in relation to Malaria Eradication programmes in the South- East Asia Region, Colombo.
28. Wickramasuriya, G.W.A (1936) *Malaria and Ankylostomiasis in the Pregnant Woman*. Oxford Medical Publications, Oxford University Press, London.